



Leo G. Hertlein

1898 – 1972

THE GEOLOGY
AND PALEONTOLOGY
OF THE MARINE PLIOCENE
OF SAN DIEGO, CALIFORNIA
(PALEONTOLOGY: PELECYPODA)

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LEO GEORGE HERTLEIN

1898-1972

Leo George Hertlein died on 15 January 1972. Dr. Hertlein was Emeritus Curator of Geology at the California Academy of Sciences, where he had worked from 1925 until his retirement in 1970. The October 1970 issue of *The Nautilus* honors Dr. Hertlein on the occasion of his retirement, and contains a biographical sketch, a list of his publications, a list of the taxa he proposed and those taxa proposed in his honor.

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FOREWORD

This portion of this monograph deals with the Pelecypoda of the San Diego Formation. The major collections upon which the present paper is based are chiefly those in the California Academy of Sciences, the Los Angeles County Museum, San Diego Society of Natural History, and the University of California at Los Angeles. These were supplemented by additional material from the collections at Stanford University and San Diego State College.

Special acknowledgment is due Mr. George P. Kanakoff, Los Angeles County Museum, who generously lent an extensive collection which he and his associates assembled in the San Diego area. This collection furnished the basis for records of many species not previously reported from the San Diego formation. A collection earlier loaned by Mrs. Kate Stephens, former Curator of Marine Invertebrates at the San Diego Society of Natural History, was supplemented by additional specimens sent by Dr. Edward C. Wilson, former Curator of Invertebrates (now with Los Angeles County Museum of Natural History), and Mr. Emery P. Chace, former Curator of Mollusks, in that institution.

Collections in greater part assembled by the late Ernest H. Quayle, which are the property of the San Diego Society of Natural History and of the University of California at Los Angeles, were lent by Mr. Takeo Susuki and Dr. Willis P. Popenoe of the latter institution.

The present paper could not have appeared in its present form without the aid and cooperation of many individuals. We are especially grateful to Dr. G D. Hanna, Curator of the Department of Geology, to Barry Roth, Curatorial Assistant in the same Department, and to Allyn G. Smith, Associate Curator of the Department of Invertebrate Zoology, California Academy of Sciences, who aided with advice and constructive criticism on many occasions. Ray Brian, librarian in the same institution aided us by making available certain of the literature pertinent to this study, and Dr. Anatole Loukashkin, Research Associate in the Department of Ornithology and Mammalogy, kindly furnished translations of some articles published in the Russian language. Others who aided in various ways include: Dr. A. Myra Keen and Dr. Eugene Coan, Stanford University; Dr. J. Wyatt Durham, and Mr. Joseph H. Peck, Jr., University of California, Berkeley; Dr. Joshua L. Bailey, Jr., San Diego Society of Natural History; the late Dr. Edwin C. Allison, and Professor E. Dean Milow, San Diego State College; Dr. Harald A. Rehder, Dr. G. Arthur Cooper, and Dr. Joseph Rosewater, United States National Museum; Dr. William K. Emerson, American Museum of Natural History; Dr. R. Tucker Abbott and Dr. Robert R. Robertson, Academy of Natural Sciences of Philadelphia; Dr. Ruth Turner, Museum of Comparative Zoology, Harvard University; Mr. F. Stearns MacNeil, Fort Myers, Florida; Mrs. Ellen Moore, United States Geological Survey, San Diego, California; Dr. Hendryk B. Stenzel, Shell Development Company, Houston, Texas; Dr. André Franc, Laboratoire de Malacologie, Museum National d'Histoire Naturelle, Paris. The aid of the other individuals will be acknowledged in the appropriate places in the text.

Most of the photographs used for illustrations on the plates were made by Mr. Maurice C. Giles, Photographer,

California Academy of Sciences, but photographs of some of the small specimens were furnished by the late Dr. G D. Hanna and Allyn G. Smith of the same institution.

The line drawings from which text figures 7, 8, 9, 10, and 13 were made, were drawn by the late Ernest H. Quayle. Text figures 11 and 12 are from drawings by Mrs. Dorothy Ludlow. The typescript was prepared by Mrs. Ludlow and Mrs. Enid Cook. Mrs. Margaret Hanna kindly retouched many of the photographs.

The cost of photography was provided by a grant, No. G17939, National Science Foundation. The authors are grateful to the individuals whose efforts facilitated this grant, and especially to Dr. David D. Keck, former Program Director, Dr. Walter H. Hodge, present Program Director, and Miss J. Frances Allen, Associate Program Director for Systematic Biology.

NEW GENERIC AND SUBGENERIC NAMES

Axinola, new subgenus

Irusella, new genus

NEW SPECIFIC AND SUBSPECIFIC NAMES

Nucula (*Ennucula*) *balboana*, new species

Mytilus (*Crenomytilus*) *coalingensis sternbergi*, new subspecies

Chlamys (*Chlamys*) *hastata ellisi*, new subspecies

Chlamys (*Argopecten*) *abietis abbotti*, new subspecies

Lima (*Limaria*) *orcutti*, new species

Aligena *diegoana*, new species

Bornia *frankiana*, new species

Dosinia *ponderosa diegoana*, new subspecies

Chione *allisoni*, new species

Chione *kanakoffi*, new species

Psephidia *stephensae*, new species

Semele *ashleyi*, new species

Thracia *kanakoffi*, new species

ABBREVIATIONS

Abbreviations following locality numbers or specimen numbers refer to the following institutions:

(ANSP) — Academy of Natural Sciences of Philadelphia

(CAS) — California Academy of Sciences

(LAM) — Los Angeles County Museum Invertebrate Paleontology

(SD) — San Diego Society of Natural History

(SDSC) — San Diego State College

(SU) — Stanford University

(UC) — University of California (Berkeley)

(UCLA) — University of California at Los Angeles

(USGS) — United States Geological Survey

(USNM) — United States National Museum

REFERENCES AND SUPPLEMENTARY DATA

All references and supplementary data are numbered consecutively within the text (in parentheses); these follow the main body of the text, starting on page 345.

PHYLUM MOLLUSCA LINNAEUS

CLASS PELECYPODA GOLDFUSS

The Pelecypoda from the San Diego formation identified in the present study, are here arranged in 4 subclasses, 8 orders, 22 superfamilies, 39 families, 82 genera and 144 species and subspecies of which 10 are not positively identified but are compared [cf. or aff.] with known species and 2 additional ones are cited as to genus only. One genus, one subgenus, 9 species and 4 subspecies are described as new. The occurrence of 11 species, one cited only as to genus, reported by other authors as occurring in the San Diego Formation, was not confirmed during the present faunal study.

The systematic arrangement in general is a combination derived from that of Dall (1)* and that of Thiele (2) with minor modifications from Cox and Newell. Families and superfamilies both are attributed to the first author who mentioned an acceptable latinized suprageneric category applicable to the group. Da Costa (3) was one of the earliest authors to apply latinized family categories to suprageneric groups of pelecypods. For example, "Family 9, is the Tellinae of Tellens." These denominations appear to be as acceptable nomenclatorially for suprageneric categories as are names used in the vernacular plural by Blainville and by Lamarck, such as "Les Tellinacées" which was latinized by later authors to Tellinidae and Tellinacea. A volume by Haas (4) contains a wealth of information concerning the classification and biology, including an extensive bibliography dealing with pelecypods. A work by Franc (5) also deals with a general treatment of this class. Publications by Habe (6), Korobkov (7), Cox (8), Newell (9) and Vokes (10) also are useful in ascertaining modern systematic arrangements of Cenozoic bivalves.

A recent publication, part of "Treatise on Invertebrate Paleontology," (11) contains an important discussion of the general features, and a comprehensive, systematic treatment of the supraspecific categories of the Pelecypoda. A paper by Böggild (12) deals with the shell structure of mollusks and a paper by Oberling (13) contains a discussion of the structural features of pelecypod shells.

The maximum depth ranges cited for the genera and species in this paper are based upon published records (14). These, however, can only be considered as representing approximate depths to which members of the genera may be found. Many of these records, where taken from the earlier literature, undoubtedly refer to the genera in a broad sense.

SUBCLASS PRIONODESMATA NEUMAYR
ORDER PALAEOTAXODONTIDA KOROBKOV
SUPERFAMILY NUCULACEA GRAY (15)
FAMILY NUCULIDAE GRAY (16)

Shell equivalve, up to 50 mm in length; roughly trigonal or oval in outline; inequilateral; posterior side short, often truncate; anterior side longer than posterior, with anterior extremity rounded. Beaks posterior,

*All references and supplementary data are numbered consecutively within the text (in parenthesis); these follow the main body of the text, starting on page 345.

opisthogyrate. A true lunule (behind the umbones) wanting; the pseudo-lunule, though sometimes lanceolate, is seldom well-defined. Below the beaks the escutcheon (occupying the position of the lunule of many pelecypods) is often heart-shaped. Prodissoconchs smooth. Sculpture, when present, consists of concentric ribs only, concentric ribs and radial ribs; bifurcating radial ribs, or modifications and combinations of these. Inner ventral margins smooth or denticulate (crenulate or pectinate). Dentition taxodont, with the longer row of teeth generally extending over the chondrophore (ligament-support). No external ligament, but an internal resilium. Pallial line entire. Shells with nacreous interiors (at least when the animal was alive); in many, if not all, species there is a differentiation of shell material, but no prismatic layer. Shells not gaping, and commonly each exhibits two subequal adductor muscle scars and additional muscle scars. The type genus is *Nucula* Lamarck, 1799. (Schenck, 1934.) Ordovician to Recent.

Remarks. — Members of this large family first appeared early in the Paleozoic era. The pearly inner layer of the shell and the presence and arrangement of the small, numerous, curved, taxodont teeth on the hinge suggest an early origin for this group. The gill structure of Recent forms is protobranch.

Schenck (17) discussed the classification of this family, as did Cox (18) who dealt especially with the derivation of the Mesozoic and Paleozoic representatives. The structure of the shell and the classification of this group was discussed recently by Van de Poel (19).

Key to Genera and Subgenera of Nuculidae

- A. Shell with divaricate sculpture *Acila*
 - a. Valves with a groove parallel to posterior margin . . . (subgenus) *Acila* s. s. (20)
 - aa. Valves lacking groove parallel to posterior margin (subgenus) *Truncacila*
- B. Shell smooth or with radial or cancellate sculpture *Nucula*
 - a. Inner margin of shell with denticles
 - b. Concentric sculpture coarse, lamellate (subgenus) *Lamellinucula*
 - bb. Concentric sculpture fine, not lamellate (subgenus) *Nucula* s. s. (20)
 - aa. Inner margin of shell smooth . (subgenus) *Ennucula*

GENUS *NUCULA* LAMARCK

Nucula Lamarck, Mém. Soc. d'Hist. Nat. Paris, p. 87, 1899. Sole species: *Arca nucleus* Linnaeus. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 110, 1931. "Type (by monotypy), *Arca nucleus* Linnaeus." — Schenck, Bull. Mus. Roy. d'Hist. Nat. Belgique, Vol. 10, No. 20, p. 18, 1934. "(Type by monotypy: *Arca nucleus* Linné)." — Hertlein and

Strong, Zoologica, Vol. 25, Pt. 4, p. 379, 1940. "Type (by monotypy): *Arca nucleus* Linnaeus."

Type species (by monotypy). — *Arca nucleus* Linnaeus [Syst. Nat., ed. 10, p. 695, 1758. "Habitat in Europa." Illustrated by Schenck, 1934, pl. 1, fig. 8; pl. 3, fig. 2; pl. 4, figs. 4, 4a, 4b; pl. 5, figs. 1, 1a. — Schenck, Proc. Malacol. Soc. London, Vol. 21, Pt. 4, fig. 1 (p. 260), March, 1935].

Range. — Jurassic to Recent. Recent in all seas; greatest number in temperate and boreal regions, from a few meters to a depth of over 3658 meters (2000 fathoms).

Description. — Shell closed, not gaping; profile ovate-trigonal; a "pouting" of the escutcheonal area, which the radial ribs do not cross; beaks opisthogyrate, appressed; prodissococonch unornamented; radial ribs faint, low, wide and flat, often difficult to see on the middle part of the shell, but they are more distinct near the ventral margin where they form the "pectinate margin"; interspaces narrow, about one-tenth the width of the ribs; interior nacreous; pallial line simple; two subequal adductor muscle scars and additional muscle scars; longer (anterior) row of teeth arched, with $16\pm$ to $24\pm$ teeth; the shorter (posterior) row straight with $7\pm$ to $11\pm$; axis of chondrophore forms an arc of a circle of which the arcuate dorsal margin is a part. (Schenck, 1934).

Remarks. — Species of this genus are generally small, many of them do not exceed 10 mm in length. *Nucula mirifica* Dall (21) living in the waters of Japan was said by its author to be probably the largest living smooth *Nucula* known. It attains a length of 36 mm. Large specimens of *Nucula compressa* Philippi from the Chattian (late Oligocene) of Belgium were reported by Schenck to be 29.3 mm long.

Trueman (22) published the results of a study of the ligament of *Nucula*. Ford (23) pointed out that the concentric rings of the shell of *Nucula nitida* do not lend themselves to a simple interpretation of the rate of growth. The habits of two species of this genus living in north European waters were described by Allen (24).

Schenck in 1934 stated that over one thousand specific names have been associated with the genus *Nucula*. A few species have been described from Tertiary strata of western North America but only two of those have been reported from beds of Pliocene age. About 20 to 22 species are known from west American waters between Bering Sea and Cape Horn.

SUBGENUS ENNUCULA IREDALE

Ennucula Iredale, Rec. Australian Mus., Vol. 18, No. 4, pp. 202, 231, June 29, 1931. "Type *Nucula obliqua* Lamarck." — Schenck, Bull. Mus. Roy. d'Hist. Nat. Belgique, Vol. 10, No. 20, p. 37, June, 1934. "(Type: *Nucula obliqua* Lamarck.)" — Hertlein and Strong, Zoologica, Vol. 25, Pt. 4, p. 382, December 31, 1940. "Type (by original designation): *Nucula obliqua* Lamarck."

Type species (by original designation). — *Nucula obliqua* Lamarck [Hist. Nat. Anim. s. Vert., Vol. 6, p. 59, 1819. "Habite les mers australes, au Cap aux Huitres." Illustrated by Schenck, 1934, pl. 3, figs. 4, 4a, 4b; pl. 4, figs. 3, 3a, 3b. Australia, Recent].

Range. — Miocene (and probably earlier) to Recent. Original descriptions. — The type species of *Nucula* is

nucleus Linné, a European species which differs appreciably from antipodean shells so classed, the latter having a notably oblique chondrophore, above which the teeth become much smaller, and the angle of opposition of the two rows of teeth is scarcely marked; further, the edge of the European shell is strongly denticulate, whereas ours is practically smooth. (Iredale, 1931.)

Remarks. — The similarity of *Ennucula* to *Leionucula* (25), which latter genus was described by Quenstedt one year earlier, was mentioned by Schenck (1934, p. 35) and later by Ichikawa and Maeda (26).

Schenck assigned subgeneric status to *Ennucula* which he placed under the genus *Nucula*. Van de Poel, more recently, considered the species of Nuculidae with non-radial structure to be referable to the genus *Nuculoma* Cossman (see Schenck, 1934, p. 26, pl. 4, figs. 5, 5a, 5b, 5c) whose type is *Nucula castor* d'Orbigny, a Jurassic species. On this basis he assigned *Ennucula* subgeneric status under *Nuculoma*. We have not studied specimens of *N. castor* and for the present at least, we leave *Ennucula* in the category assigned to it by Schenck.

About 20 species were placed in *Ennucula* by Schenck and he listed thirteen additional species which may be referable to this subgenus. Six species from the Cenozoic of western North America have been referred to *Ennucula*. One new species from the Pliocene of San Diego is added in the present paper.

Nucula (*Ennucula*) *balboana* n. sp.

Plate 27, Figures 1, 2, 3, 4

"*Nucula*, sp. n. according to Dr. Cooper," Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, December, 1874. "Well at San Diego." — Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 85, August, 1889. Dall's (1874) record cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Orcutt's citation of Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record cited. (Not *Nucula exigua* Sowerby).

Holotype and paratypes in the California Academy of Sciences Department of Geology Type Collection, from the San Diego well in Balboa Park, San Diego, California; H. Hemphill, collector; Pliocene.

Range. — Known only from the type locality.

Descriptions. — Shell ovately triangular, smooth, beaks opisthogyrate, placed near posterior end, a lanceolate depressed area beneath them; the posterior margins of the valves slightly projecting; a narrow area along the anterior dorsal margin slightly depressed; anterior margin broadly rounded, the anterior end elliptically rounded, the posterior end slightly rounded and abruptly truncated; surface of valves with fine concentric lines of growth, toward the anterior margin with occasional minute constrictions; inner margin of shell smooth and devoid of denticles. Portions of two paratypes reveal the presence of about 18 teeth in the anterior series and about 8 or 9 in the posterior series. The chondrophore projects obliquely anteriorly. Dimensions of holotype: length, 13.4 mm; height, 10.7 mm; convexity (both valves together slightly gaping due to enclosed sediment), 7.2 mm.

Remarks. — The species here described as new closely resembles *Nucula quirica* Dall (27) but differs in

that the shell is more elongate in proportion to the height, the anterior margin is correspondingly less broadly rounded, and so far as known there is no trace of fine radial striae on the interior of the valves.

Schenck (28) considered *N. quirica* to be a probable synonym of *Nucula bellotii* A. Adams (29) but judging from his illustrations (30) of that species the shell is less abruptly truncated posteriorly and the anterior dorsal margins of the valves are more inflated than that of Dall's species.

The present specimens, collected by Henry Hemphill from the San Diego well, are probably from the original lot which Dall identified as a new species of *Nucula* which "Looks much like *N. tenuis*."

SUBGENUS *LAMELLINUCULA* SCHENCK

Lamellinucula Schenck, Jour. Paleo., Vol. 18, No. 1, p. 97, January, 1944.

Type species (by original designation). — "*Nucula lamatavica* Odhner (1943, p. 206), new name for *Nucula rugosa* Odhner (1919, pp. 23-24, pl. 2, figs. 15-18); Recent, Madagascar." [See Odhner, K. Svensk Vetenskaps Arkiv för Zool., Bd. 12, No. 6, p. 23, pl. 2, figs. 15-18, 1919. Also illustrated by Schenck, 1944, p. 98, fig. 1.]

Range. — Eocene (31) to Recent. Recent, world-wide, in 5 to 219 meters (3 to 120 fathoms), questionable below 1829 meters (1000 fathoms) according to Schenck.

Original description. — The subgenus is proposed for nuculid pelecypods ranging in length up to about 25.0 mm; shell closed, not gaping; dorsal margin straight to gently arched; anterior extremity bluntly rounded (see fig. 1); ventral margin convex; posterior margin straight to convex; lunule and escutcheon indistinct to moderately well defined; beaks intumed, opisthogyrate; interior nacreous; taxodont dentition consisting of about 12 to 26 teeth in the anterior (long) series, 4 to 12 in the posterior (short) row; chondrophore distinct, sometimes heavy; two subequal adductor muscle scars and accessory scars as in other members of the family; pallial line entire; inner ventral margin denticulate (crenulate, crenate); incised, lamellate concentric sculpture more conspicuous than radial ribs or striae; from two to eight concentric ribs per millimeter. (Schenck.)

Remarks. — Twenty species and subspecies, described under the genus *Nucula*, were referred to *Lamellinucula* by Schenck and he mentioned thirteen others which may be referable to this category.

Glibert and Van de Poel (Mém. Inst. Roy. Sci. Nat. Belgique, Deuxième Sér., Fasc. 77, p. 15, 1965) suggested the possibility that the type of ornamentation on *Lamellinucula* may be polyphyletic.

Nucula (Lamellinucula) exigua Sowerby
Plate 27, Figures 5, 6

Nucula exigua Sowerby, Proc. Zool. Soc. London for 1832, p. 198 (issued March 13, 1833). — Sowerby, Conch. Illustr., Nuculae, Catalogue, Pt. 16, p. 6, pl. 16, figs. 24, 24*, issued January 18, 1833. (Reprinted Cat., p. 6, 1841.) "Bay of Caraccas." — Hanley, Thes. Conch., Vol. 3, p. 154, pl. 229, (Nuculidae, pl. IV), fig. 136, 1860. "Bay of Caracas, W. Columbia." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. "well-

digging in stratum B²." Pliocene. Other localities (pp. 11, 27), probably Pleistocene. — Cooper, Calif. State Mining Bureau, Seventh Ann. Rept. State Mineralogist, Vol. 7, p. 254, 1888. "Pl. — San Diego well." — Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 86, August, 1889. Dall's record (1874) cited. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 577, 1898. "San Diego, California, well." "Pliocene." — Orcutt, quoted by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 60, 1919. Dall's record (1874) cited — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 13, 1924. "In the Pliocene of San Pedro and San Diego, California." Also Recent.

Nucula (Nucula) exigua Sowerby, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 111, 1931. "San Diego well" (Dall's record, 1898, cited), Pliocene. Also cited from Merced and Wildcat Formations and Pleistocene and Recent. — Schenck, Jour. Paleo., Vol. 13, No. 1, p. 36, pl. 6, figs. 1-8, 11, 1939. Recent. — Hertlein and Strong, Zoologica, Vol. 25, Pt. 4, p. 381, pl. 1, figs. 4, 5, 1940. Corinto, Nicaragua, Recent. Also earlier records.

Nucula exigua Sowerby, Palmer, Geol. Soc. Amer., Mem. 76, p. 61, pl. 1, figs. 6, 7, 1958. Syntype of "*N. suprastrata* Cpr.", from "Catalina 30 fms. Cooper." Not *Nucula suprastrata* Carpenter in Arnold, 1903. *Nucula (Nucula) exigua* Sowerby, Olsson, Mollusks of Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 56, pl. 1, figs. 2, 2a, 2b, 10, 10a, 1961. Lower California to Peru.

Type specimen. — British Museum (Natural History).

Type locality. — "Hab. ad Columbiam Occidentalem (Bay of Caraccas)." [Ecuador, Lat. 00° 35' S.] "A single specimen found in sandy mud at nine fathoms depth."

Range. — Middle Pliocene to Recent. Recent from Bahía Tortolo (Turtle Bay), Lower California, to the Gulf of California, and south to Ecuador, in 16 to 24 meters (9 to 13 fathoms); 1207 to 1895 meters (660 to 1036 fathoms) (Dall).

Occurrence in San Diego Fm. — U.C.L.A. 312.

Original description. — Nuc. testâ parvâ, oblique ovatâ, albicante, pellucidâ, concentricè sulcatâ; latere postico longiore, subacuminato, antico brevissimo: long. 0.2, lat. 0.1, alt. 0.15 poll. (Sowerby.)

Remarks. — This species was reported by Dall from diggings of the San Diego well and that record was cited by several authors.

One left valve and two imperfect right valves, one of which is about 5 mm in altitude, are present in the collections from near the United States-Mexico boundary. These retain traces of radial striae, crossing the stronger concentric ribbing, over most of the surface of the valves. This feature, however, varies in a series of Recent specimens of this species as does the amount of escutcheonal projection.

Nucula suprastrata Carpenter in Arnold (32), a similar species or subspecies, is said to differ from *N. exigua* in the greater size (up to 7 mm in length), the more impressed lunule and escutcheon, and in that the radial sculpture usually is present only toward the base of the valves. These differences, as mentioned by Schenck, are found to be less constant when a large series of specimens is examined. Schenck concluded that greater size is the

most reliable criterion for separating *N. suprastrata* from *N. exigua*.

A consideration of the foregoing in connection with study of the present fossils from the San Diego formation leads us to refer them to *N. exigua*.

Adequate discussion and illustration of Recent specimens of *Nucula exigua* have been given by Schenck and by Hertlein and Strong.

Nucula paytensis A. Adams (33) as pointed out by Hertlein and Strong, apparently is more rounded in outline and the escutcheon area is more projecting than that of *N. exigua*. Schenck (1944, p. 98) considered it to be a synonym of *N. exigua* and Olsson (1961, p. 56) suggested that intergradation between the two may occur.

Nucula vieta Guppy described from strata of late Miocene age in Trinidad is a very similar species (see Jung, Bull. Amer. Paleol., Vol. 55, No. 247, p. 316, pl. 13, figs. 4-7, 1969).

Nucula cahuitensis Olsson (34) described from strata of Miocene age in Costa Rica, was compared by its author with *N. exigua*.

Nucula venezuelana Weisbord (35) described from beds of Pliocene age in Venezuela is another similar species.

GENUS *ACILA* H. AND A. ADAMS

Acila H. and A. Adams, Gen. Rec. Foss. Moll., Vol. 2, p. 545, January, 1858. Species cited: "*castrensis*, Hinds," "*divaricata*, Hinds," "*mirabilis*, Adams and Reeve." — Kobelt, Illustr. Conchylienbuch, Bd. 2, Lief. 10-11, p. 371, 1881. "Typus *Nucula divaricata* Hinds (Taf. 109 Fig. 18)." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 112, November 3, 1931. Type as designated by Stoliczka, 1871. — Schenck, Geol. Soc. Amer., Spec. Papers No. 4, p. 23, 1936. Type as designated by Stoliczka, 1871.

Type species (designated by Stoliczka, Mem. Geol. Surv. India, Palaeo. Indica, Ser. 6, Cret. Fauna South India, Vol. 3, pp. XXI, 325, 1871). — "*N. divaricata*, Hinds, is the type." [Proc. Zool. Soc. London for 1843, p. 97, issued December, 1843. "Hab. China Sea; from eighty-four fathoms." "Cab. Belcher." Illustrated by Hinds, Zool. Voy. Sulphur, Moll., Pt. 3, p. 62, pl. 18, fig. 4, 1844 (January, 1845, on cover of Pt. 3). — Schenck, 1936, pl. 15, figs. 1-10, text fig. 8 (1, 2).]

Range. — Early Cretaceous (Aptian) to Recent. Recent in Indo-Pacific waters at depths of about 9 to 1500 meters (5 to 820 fathoms) but usually in less than 914 meters (500 fathoms), in fine-grained sediment, and bottom temperatures between 4.4° to 21.1° C. (40° to 70° F.) but species have been taken in 1.11° C. (34.0° F.) and 23.9° C. (75° F.).

Description. — Like *Nucula* but often larger (max. length about 50 mm), the surface sculptured with a characteristic pattern of parallel divaricating and more or less radial riblets which appear as if stacked or packed close together the main line of divarication extending from the umbo across the middle of the shell disk to the ventral margin, the peaks of their inverted V's forming a line of sharp, acute angles pointing toward the beak. A secondary line of reversed divarication may be developed along the posterior rostral side which forms a shallow sinus ending in a slight bulge or pout at the margin. (Olsson, A. A., Mollusks of the Tropical eastern Pacific (Paleo. Res. Inst.:

Ithaca, New York), p. 57, 1961.)

Remarks: The shells of this genus are closed, equivalve, inequilateral and trigonal or ovate to quadrangular in outline similar to *Nucula*. They attain a length of about 50 mm and a height of often about 75 per cent of the length. The beaks are opisthogyrate; interior nacreous; dentition taxodont.

A thorough monographic study of *Acila* and its species by Schenck (36) in 1936 has been the source of most of our information concerning the ecology of this group. According to Schenck *Acila* s. s. is known to range from "Oligocene (?) to Recent."

Key to Subgenera of *Acila*

A. Well defined rostral sinus present . . . *Acila* s. s.

B. Well defined rostral sinus lacking . . . *Truncacila*

SUBGENUS *TRUNCACILA* SCHENCK IN GRANT AND GALE

Truncacila Schenck MS., in Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 115, November 3, 1931. — Schenck, Geol. Soc. Amer., Spec. Papers No. 4, p. 23, 1936. "Genotype: *Nucula castrensis* Hinds, by original designation."

Type species (by original designation). — "*Type: Nucula castrensis* Hinds."

Range. — Cretaceous to Recent.

Description. — Adult shell seldom exceeds 30 millimeters in length; trigonal; quadrangular or ovate in outline; lacking the well-defined rostral sinus that characterizes *Acila*, *sensu stricto*; one or more bifurcations (divarications) of the radial ribs. (Schenck, 1936.)

Remarks. — Schenck listed 17 species and subspecies definitely referable to *Truncacila* and several others doubtfully belonging to this subgenus.

One species, the type of this subgenus, occurs in the San Diego formation.

Acila (Truncacila) castrensis Hinds Plate 27, Figures 7, 8, 9, 10

Nucula castrensis Hinds, Proc. Zool. Soc. London for 1843, p. 98, issued December, 1843. — Hinds, Zool. Voy. Sulphur, Moll., Pt. 3, p. 63, pl. 18, fig. 5, 1844 (January 1845 on cover of Pt. 3). — Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 204, 1909. Quillayute Formation, western Washington, Pliocene. Also "Purisima-San Diego" formation in California. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 182, 1912. "San Diego-Purisima." — I. S. Oldroyd, Stanford Univ. Publ. Ser. Geol. Sci., Vol. 1, No. 1, p. 14, pl. 5, fig. 11; pl. 37, figs. 1, 2, 1924. Recent. Also "Pliocene" at "San Diego." — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 84, 1929. "San Diego Pliocene." *Acila lyallii* Baird, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "Well at San Diego." — Dall, Proc. U. S. Nat. Mus., Vol. 1, No. 2, p. 28, 1878. "well-digging in stratum B²," San Diego. — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, August, 1889 (as *Acila lyalli*). Dall's record (1874) cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper

446, p. 59, 1919 (as *Acila lyalli*). Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) cited.

Acila castrensis Hinds, Cooper, Calif. State Min. Bur., Seventh Ann. Report of State Mineral. Vol. 7, p. 227, 1888. "San Diego well, "Pliocene." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Quotation of Dall's record (1874). — Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, 1941. "? Strata penetrated by well in San Diego."

Nucula (Acila) castrensis Hinds, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 95, 1903. Cooper's record (1888) cited from San Diego well. — Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 174, 1909. The record "San Diego (Cooper)". — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 116, pl. 1, figs. 6a, 6b (Recent), 1931. ?Miocene; Pliocene to Recent. Also "San Diego well, San Diego (Cooper)."

Acila (Truncacila) castrensis Hinds, Schenck, Geol. Soc. Amer., Spec. Papers No. 4, p. 96, pl. 10, figs. 1-5 (Recent), text fig. 7 (2-5), 1936. Pliocene to Recent. From San Diego Pliocene at "loc. 331 [SD], ravine 200 feet north of Mexican boundary, 3/4 mile east of coast," Pliocene.

Type specimen. — Present disposition unknown (according to Schenck).

Type locality. — "Hab. Sitka, North-west America. A single specimen was dredged in the harbour, from seven fathoms, sand." (Hinds.)

Range. — Pliocene to Recent. Recent, Sitka, Alaska, to Cedros Island, Lower California, Mexico, in 9 to 1280 meters (5 to 700 fathoms).

Occurrence in San Diego Fm. — Well at San Diego (Dall). C.A.S. 12099, 28889, 28892. L.A.M. 104, 107, 305. S.D. 331. U.C. A-8333. U.C.L.A. 294, 295, 309, 312, 2359.

Original description. — Nuc. testâ ellipticâ, anticè rotundatâ, epidermide olivaceâ indutâ; lineis divaricatis; marginibus ventralibus crenulatis; cardine anticè dentibus 5, posticè 11. Long. 3; lat. 1 1/2; alt. 2 lin. (Hinds.)

Remarks. — Three specimens of this posteriorly truncate species, one with both valves, and two single valves, are present in the Henry Hemphill collection of the California Academy of Sciences from the San Diego well. The largest specimen, a single valve, is approximately 9 mm long, 7.3 mm high, convexity, 2.4 mm. The shape and sculpture of these specimens are similar to that of specimens of comparable size now living in west American waters.

Over a hundred specimens of this species were collected by Kanakoff at Loc. 305 (LAM), near the United States-Mexico boundary. The largest valve is 11 mm long and 8.8 mm high. A cast from Loc. 104 (LAM), is 12.8 mm in length.

Schenck's careful study (1936) of *Acila castrensis* indicated that specimens occurring in the waters of southern California attain maximum lengths of about 12 mm, but that those occurring in the waters of Washington and Alaska may attain a length of 20 mm, and a height of 16 mm. He also mentioned that the anterior series of teeth may range to 24 in number and the posterior series to 12. The height in some specimens may range

from 74 to 90 per cent of the length. Frizzell (37) published the results of a study of the variation in the sculpture of 358 specimens from Puget Sound. The soft parts of *A. castrensis* were studied by Heath (38).

Acila castrensis has been recorded from various localities in California in beds of Pliocene and of Pleistocene age. The records of its occurrence by Khomenko (39) in strata of late Tertiary age on the Schmidt Peninsula, Kamtschatka, and that of Simonova (40) from east Sakhalin, need confirmation.

FAMILY NUCULANIDAE H. AND A. ADAMS (41)

Shell similar to the Nuculidae but elongated, the posterior side longer, narrower, often rostrate, and partly gaping at the end; the anterior end shorter, more rounded and convex; hinge and ligament as in the Nuculidae, the resilium sometimes external or lacking; internal shell layer subnacreous in the early forms but mostly porcelaneous in more Recent forms; mantle lobes more or less united; with siphons; pallial line usually sinuated. Devonian to Recent.

Remarks. — Stenzel et al., 1957, placed this family under a Superfamily "Nuculanicae". McAllister, 1964, also favors assigning a superfamily ("Nuculanicea") to this group of mollusks.

Dell (42) cited about 90 names (some homonyms, synonyms, or unacceptable for various reasons) which have been proposed for supraspecific units of this family. Verrill and Bush (43) published a revision of the Nuculanidae of the Atlantic Coast of the United States.

Most of the Recent species of this family live on muddy bottoms.

Key to Genera of Nuculanidae

- A. Shell closed (or nearly so) posteriorly;
pallial sinus usually shallow *Nuculana*
- B. Shell gaping posteriorly; pallial
sinus usually deep *Yoldia*

GENUS NUCULANA LINK

Nuculana Link, Beschreib. Nat. — Samml. Univ. Rostock, Abt. 3, p. 155, May 17, 1807. Sole species: "*N. rostrata*." Ref. to Gmelin, p. 3308, and to Chemnitz, Vol. 7, pl. 55, figs. 550, 551. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 118, 1931. "Type (by monotypy) *Arca rostrata* Chemnitz." — Hertlein and Strong, Zoologica, Vol. 25, Pt. 4, p. 390, 1940. "Type (by monotypy): *Arca rostrata* Chemnitz." — Cox, Mem. Geol. Surv. India, Palaeo. Indica, Ser. 9, Vol. 3, Pt. 3, p. 26, 1940. "Genotype: *Arca rostrata* Chemnitz."

Leda Schumacher, Essai Nouv. Syst. Test., pp. 55, 172, 173, 1817. Type indicated as *Arca rostrata* Chemnitz, illustrated by Schumacher on pl. 19, fig. 4.

Type species (by monotypy). — *Arca rostrata* Chemnitz [= *Mya pernula* Müller]. [*"Arca Martini rostrata"* Chemnitz, Neues Syst. Conchyl. — Cab., Bd. 7, p. 206, pl. 55, figs. 550, 551, 1784. "Sie werde schon ohnweit Helsingburg in einen Meerbusen bey Kullen, und noch häufiger bey Norwegischen Stranden gefunden." —

Schenck, Bull. Mus. Roy. d'Hist. Nat. Belgique, Vol. 10, No. 20, pl. 1, fig. 2, 1934 (hinge of *Nuculana pernula* Müller). — Habe, Gen. Jap. Shells, Pelecypoda, No. 1, p. 24, 1951. Type species: *Arca rostrata* Bruguière. (Figs. 20, 21, *Nuculana pernula* Müller.)]

Range. — Jurassic (perhaps Triassic) to Recent. Recent, world-wide, abundant in cool marine waters, 5 to 3658 meters (3 to 2000 fathoms).

Description. — Shell elongate, often somewhat crescent-shaped, usually rostrate and somewhat carinate posteriorly bounding an escutcheon; valves closed or gaping slightly at the posterior end; beaks small, opisthogyrate; sculpture consisting chiefly of concentric threads, more closely spaced toward the ventral margin; resilium on a small, triangular chondrophore, inclined posteriorly under the beaks and separating two series of teeth, the posterior series about twice as numerous as the anterior series; this arrangement of the resilium is present in Cenozoic forms but in some earlier groups it is nearly lacking and the ligament is entirely posterior to the beaks; pallial line sinuous in Recent forms but in some early forms it is only slightly or not sinuated.

Remarks. — About 20 species of this genus have been described from Tertiary strata in California and about 60 species have been recorded occurring in the marine waters of the western Americas between Bering Sea and Cape Horn. Only about four species have been recorded from beds of Pliocene age in western United States, one of which occurs in the San Diego formation.

Cox, 1940, discussed some of the Mesozoic *Nuculana*-like forms. He pointed out that many Jurassic species are referable to the genus *Nuculana* but that it is doubtful whether they are referable to Recent subgenera. Some of the Jurassic species possess nacreous shells and some species have an entire, not sinuated pallial line.

SUBGENUS *NUCULANA* S. S.

Nuculana (*Nuculana*) aff. *N. (N.) leonina* Dall

Plate 57, Figures 17, 20

The following references refer to typical *N. leonina*. *Leda leonina* Dall, Nautilus, Vol. 10, No. 1, p. 2, May, 1896. "Off Sea Lion Rock, Coast of Washington in 477-559 fathoms, mud, U. S. Fish Commission." — Dall, Bull. Nat. Hist. Soc. Brit. Columbia, No. 2, p. 7, pl. 2, fig. 12, January, 1897. "dredged by the U. S. Fish Commission in the Straits of Fuca and off Sea Lion Rock on the coast of Washington, in 477-559 fathoms." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 21, pl. 13, fig. 18, 1924. Type locality cited. "Range. Strait of Juan de Fuca to latitude 36 north."

Occurrence in San Diego Fm. — L.A.M. 305A.

Remarks. — A right valve of a *Nuculana*, 8.6 mm long and 4.8 mm high, is present in the collections from near the Mexican boundary. The exterior sculpture is comprised of ten narrow, elevated ridges between which in some areas there are traces of minute concentric striae. A narrow shallow depression just below the dorsal posterior margin extends from near the beak to the posterior end of the valve.

The present specimen bears a general resemblance to *Nuculana leonina* Dall but is less rostrate, higher in

proportion to the length, has much wider interspaces between the concentric ridges and fewer hinge teeth.

There is variation in the sculpture in a series of specimens of *N. leonina* but none that we have seen have nearly such wide interspaces between the concentric ridges and all have many more teeth on the hinge.

The present fossil probably represents an undescribed species, but because only one small valve which has undergone some erosion is available, we merely report its occurrence and call attention to its general similarity to *N. leonina*.

SUBGENUS *SACCELLA* WOODRING

Ledina Sacco, Moll. Terr. Terz. Piemonte e Liguria, Pt. 26, p. 53, December, 1898. "(Tipo *L. fragilis* (Chemnitz))". Not *Ledina* Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 580, April, 1898. "Type *L. eborea* Conr., 1860, not 1846, = *L. smirna* Dall, Eocene."

Saccella Woodring, Carnegie Inst. Washington, Publ. 366, p. 15, May 20, 1925. "Type (by original designation). — *Arca fragilis* Chemnitz (= *Leda commutata* Philippi)." — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. 3, p. 53, 1930. Type as indicated by Woodring. — Hertlein and Strong, Zoologica, Vol. 25, Pt. 4, p. 392, 1940. "Type (by original designation): *Arca fragilis* Chemnitz."

Type species (by original designation). — *Arca fragilis* Chemnitz [Neues Syst. Conchyl. -Cab., Bd. 7, p. 199, pl. 55, fig. 546, 1784. "Mittelländischen Meeres." — Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 5 (Pelecypoda, Fasc. 18), p. 215, pl. 37, figs. 26-31, 1891 (= *Nucula commutata* Philippi). Mediterranean and east Atlantic. Miocene to Recent].

Range. — Paleocene (Midway) to Recent (Gardner, Bull. Amer. Assoc. Petrol. Geol., Vol. 25, No. 4, p. 647, 1941).

Description. — Shell small, high, slightly inequilateral, posterior end rostrate, rostrum sharply pointed and unicarinate; a shallow groove extends from the umbo to the ventral margin at both ends of the valve; sculpture consisting of strong concentric rugae; hinge like *Leda* s. s., but the anterior and posterior series of teeth are approximately equal in length; apex of pallial sinus broadly U-shaped. (Woodring, 1925.)

Remarks. — The shell of *Saccella* differs from that of *Lembulus* Risso (44) in that it has concentric instead of diagonal sculpture and also it has a narrower and shallower posterior groove.

Another genus, *Jupiteria* Bellardi (45), type *Nucula concava* Bronn, has a hinge similar to that of *Saccella* but the shape of the shell is more like that of *Corbula* and the exterior bears very fine, regular, concentric sculpture.

Praesaccella Cox (46) described from beds of Jurassic age in India is said to differ from *Saccella* in that the pallial line lacks a sinus and the hinge teeth are larger and less numerous.

Mesosaccella Chavan (47), described from strata of late Cretaceous age in Europe, has an external ligament situated just posterior to the beaks. The series of teeth continue beneath the beaks where they are elevated. There is no well defined ligamental pit, the fossette is merely a vague triangular depression formed by an enlargement of the cardinal margin.

Nuculana (Saccella) taphria Dall

Plate 27, Figures 11-13, 16-18

Nucula caelata Hinds, Proc. Zool. Soc. London, p. 99, December, 1843. — Hinds, Zool. Voy. Sulphur, Moll., Pt. 3, p. 64, pl. 18, fig. 13, 1844 (January 1845 on cover of Pt. 3).

Not *Nucula coelata* Conrad, Amer. Jour. Sci., Vol. 23, No. 2, p. 343, January, 1833. Claiborne, Alabama. London clay [Eocene].

Leda caelata Hinds, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, December, 1874. "well at San Diego." "Pliocene." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11 (well at San Diego), p. 28 ("well-digging in stratum B²"), 1878. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 48, 1944. Dall's record (1874) cited.

Leda caelata Hinds, Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., Vol. 7, p. 245, 1888. "San Diego well." Pliocene. — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, August, 1889. Dall's record (1874) cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Orcutt's citation of Dall's record (1874).

Leda taphria Dall, Nautilus, Vol. 10, No. 6, p. 70, October, 1896. New name for *Nucula "coelata"* Hinds, 1843, not *Nucula coelata* Conrad, 1833. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 98, pl. 17, fig. 5 (lower San Pedro Series), 1903. "San Diego well (Cooper)" and "Pliocene of Pacific Beach". — Arnold, U. S. G. S., Prof. Paper 47, p. 28, 1906. "San Diego formation." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 172, 1912. "San Diego-Purissima." — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Sci., Vol. 18, No. 3, table opp. p. 78, 1929. "San Diego Pliocene". Also other formations.

Nuculana taphria Dall, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 121, pl. 1, fig. 8 (Holser Canyon, Pliocene), fig. 9 (near Goleta, California, Pleistocene), 1931. "San Diego formation of Reynard Way, San Diego," also record of Arnold (1906) and Cooper (1888) cited.

Saccella taphria Dall, Moore, San Diego Soc. Nat. Hist., Occ. Paper 15, p. 50, pl. 23, figs. e, f, g, 1968. Balboa Park; Pacific Beach, Pliocene. Also other localities. Also Miocene to Recent.

Type specimen. — Location unknown to the present authors. Originally in "Cab. Belcher." Not found in British Museum by Keen (Veliger, Vol. 8, No. 4, p. 267, 1966).

Type locality (of *Nucula caelata*). — "Hab. California, between 38° 18' and 34° 24' north latitude; namely, at Russian Bodegas, San Francisco, and Santa Barbara, in from six to ten fathoms."

Range. — Late Miocene (Briones); Pliocene to Recent. Recent from Bodega Bay, California, to Punta Arena, Lower California, in 5 to 93 meters (3 to 51 fathoms).

Occurrence in San Diego Fm. — Well at San Diego (Dall). C.A.S. 1400, 1401, 1402, 1404, 28889. L.A.M. 104, 107, 305, 305A, 305C, A1323. S.D. 29, 75, 80. U.C. A-8333. U.C.L.A. 294, 1386, 2359.

Original description of *Nucula caelata* Hinds. — Nuc.

testâ luteo-virente, oblongâ, argutè sulcatâ; antieè arcuatè rostratâ, sulcis paululùm oblitteratis; umbonibus prominulis. Long. 7; lat. 3; alt. 4 lin. (Hinds.)

Remarks. — The description attributed to Dall by I. S. Oldroyd, 1924, is from Arnold, 1903.

The umbos of *Nuculana taphria* are nearly centrally situated, the rostrum is bluntly pointed and the exterior is sculptured with well developed, uniform, sharp, raised, concentric ribbing. A narrow lunular area is present and there is a long, narrow escutcheon concentrically striated. A narrow, shallow, depressed area extending from the umbos to the ventral margin is usually present just anterior to the dorsal margin. There are two gently curved rows (the anterior slightly the longer) of chevron-shaped teeth, about 20 in each series. A shallow pallial sinus is present. A typical specimen from off San Martin Island, Lower California, is 18 mm long, 11.2 mm high, convexity (both valves together), 8.9 mm.

Heath (48) described the soft parts of this species.

We have examined over two hundred specimens, ranging from 3 to 22.6 mm in length, collected by George Kanakoff at Loc. 305 (LAM), near the Mexican boundary, and find variation fully as great as in a similar series of Recent shells. Larger shells tend to be more globose with the posterior end more pointed and upturned. Some of these have been bored on the umbo by a gastropod.

When Dall, 1896, proposed the new name, *Leda taphria* for *Nucula caelata* Hinds (non Conrad), he gave no description nor did he cite any type specimen.

Mrs. Ellen J. Moore, United States Geological Survey, examined specimens in the United States National Museum which were labelled *Nuculana taphria* by Dall, and furnished us information concerning them which we include here.

She stated (49) that a specimen, No. 122579 (USNM), 18 mm long, entered in the catalogue on July 25, 1891, was labelled by Dall "*Leda taphria* Dall, (Fig'd.), Sta. 3147, 56 fms., mud, 49.2°, off Pt. Año Nuevo, Cala." Another specimen, No. 107432 (USNM), 17.2 mm long, entered in the catalogue April 13, 1896, was labelled "*Leda caelata* Hinds, Fig'd., 56 fms., off Pt. Año Nuevo, Cala. USFC." In the vial with the specimen there is a printed slip by Dall, stating "Fig'd. type." This specimen compares favorably with the specimen illustrated by Dall in 1897 which he stated was 17 mm long. Furthermore, Mrs. Moore stated that neither of the specimens mentioned above were entered as types in the catalogue and both were in the general collection of mollusks.

It appears to us that Dall originally made a simple substitution of the name *taphria* for *caelata* Hinds and Dr. H. A. Rehder (50), United States National Museum, concurs in this opinion. We, therefore, consider the specimen illustrated as *Nucula caelata* by Hinds to be the type of *Nuculana taphria*.

The original figure by Hinds is 13 mm long. Compared with this the specimen illustrated by Dall, 1897, is more globose, slightly higher in proportion to the length and it is posteriorly slightly more concave and pointed. Through the courtesy of Dr. Harald Rehder, we were able to examine this specimen illustrated by Dall. The dimensions are approximately, length, 17.2 mm, height, 11.4 mm, convexity (both valves together), 9.2 mm. In view of the variation in this species, we are inclined to consider both illustrations as representing the same species.

The shell of this species is less elongate, more inflated, and the surface is less polished than that of *Nuculana callimene* Dall (51) from Panama and it has much coarser sculpture than that of *N. pontonia* Dall (52), originally described from the Galápagos Islands. The presence of an anterior lunular area on *N. taphria* serves to separate it from the similar *N. balboae* Brown and Pilsbry (53) from mid-Miocene strata of Panama. Furthermore, the Panamanian species has a much greater number of teeth, 28 in the anterior and 18 in the posterior series.

A species recently described as *Saccella calkinsi* by Moore (54) from the Astoria formation of middle Miocene age in Oregon, is said to differ from *N. (S.) taphria* in the less strongly recurved rostrum, narrower, longer escutcheon and narrower and less ovate lunule.

Nuculana taphria has been reported by some authors (55) as definitely identified from strata of late Miocene age but others (56) have cited it with doubt as "*Leda* cf. *taphria* Dall" from beds of similar age. Records of its occurrence in the later Tertiary of Kamtschatka (57) and in Sakhalin (58) may be open to question.

GENUS YOLDIA MÖLLER

Yoldia Möller, Naturhist. Tidsskrift, Bd. 4, No. 1, p. 91 (also separately, Index Moll. Groenlandiae, p. 18), 1842. Species cited: "*Y. arctica*, *Nucula arctica* Gray" and "*Y. angularis* nob., *Nuc. myalis* Couth.?" — Verrill and Bush, Proc. U. S. Nat. Mus., Vol. 20, No. 1139, p. 858, June, 1898. "Type. — *Yoldia hyperborea* Torrell = *Yoldia arctica* Möller (not Gray)." — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 59, 1930. Type designation of Verrill and Bush accepted. — Kanno, Jap. Soc. Promotion of Sci., Neno, Tokyo, p. 198, 1960. Type: *Nucula arctica* Möller.

Type species (designated by Verrill and Bush, 1898. Also by the Internat. Comm. Zool. Nomencl., Opinion 769, Bull. Zool. Nomencl., Vol. 23, Pt. 1, p. 33, April 29, 1966). — "the nominal species *Yoldia hyperborea* Torell, 1859, is hereby designated to be the type-species of that genus." [*Yoldia hyperborea* Torell, Bidrag till Spitzbergens molluskfauna (Stockholm), pp. 149-150, tab. 2, figs. 6a, 6b, 1859. — Ockelmann, Medd. om Grønland, Bd. 107, No. 7, pl. 1, fig. 1; pl. 2, fig. 3, 1954. — Cowan, Veliger, Vol. 11, No. 1, p. 58, pl. 5, figs. 6 (Point Barrow, Alaska), 7 (Disco, Greenland), 1968.]

Range. — Late Cretaceous to Recent. Recent chiefly in boreal and temperate waters, 0 to 5303 meters (0 to 2900 fathoms).

Description. — Somewhat similar to *Nuculana* but with thinner, subovate shell, slightly rostrate, usually gaping posteriorly; exteriorly sculptured by growth lines on concentric striae; hinge consisting of two subequal series of small chevron-shaped teeth; resilium-pit large, symmetrically underlapping both rows of teeth; pallial sinus deep and wide, the apex broadly U-shaped. (Hertlein and Strong.)

Remarks. — The species of *Yoldia* are most abundant in boreal waters. In western North America 21 species have been reported living in waters between Bering Sea and San Diego, California, and about a dozen species have been reported in the region between Cedros Island, Lower

California, Mexico, to southern Chile. Fourteen species have been reported from strata of Tertiary age in California, five of them in strata of Pliocene age in California and two in Oregon. The genus is here reported from the San Diego Formation for the first time.

Uozumi (59) discussed many of the Japanese fossil forms of *Yoldia* and Ockelmann (60) remarked on the relationships of various North Atlantic species of this genus.

SUBGENUS KALAYOLDIA GRANT AND GALE

Kalayoldia Grant and Gale, new section, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 128, November 3, 1931.

Type species (by original designation). — *Yoldia cooperii* Gabb.

Range. — Oligocene (Eugene formation), to Recent.

Original Description. — Like *Yoldia*, s. s., but posterior dorsal margin of shell curved, concave upward, typically much shorter than anterior dorsal margin; posterior portion of valves rostrate, typically somewhat narrowed vertically; sculpture consisting of definite concentric riblets; hinge with a long, gently curved anterior row of teeth, separated by a relatively large, shallow, ovate ligamental pit from the very short, nearly straight posterior row of teeth; pallial sinus large and deep. (Grant and Gale.)

Remarks. — Six or seven species described from the late Cenozoic of western North America are referable to this subgenus. The single Recent species, the type species of this group, ranges from central California to northern Lower California, Mexico.

Yoldia (Kalayoldia) cf. *Y. (K.) cooperii* Gabb

The following references, type specimen, type locality, range and description, refer to typical *Y. cooperii*. *Yoldia cooperii* Gabb, Proc. Calif. Acad. Nat. Sci., Vol. 3, p. 189, January, 1865. — Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 31 (in part), pl. 9, fig. 54 (as *Y. cooperi*), 1866. "picked up by Dr. Cooper on the beach at Santa Cruz." — Schenck and Keen, California Fossils for the Field Geologist (Stanford Univ.: Calif.), 1940, pp. 65, 69, 80 (pp. 67, 71, 82, ed. 1950), pl. 1, fig. 3; pl. 4, fig. 12. Halfmoon Bay, California, Recent.

Yoldia cooperi Gabb, Packard, Univ. Publ. Zool., Vol. 14, No. 2, p. 248, pl. 14, fig. 9, 1918. "dredged alive outside the Golden Gate, in 68 fathoms and on a bottom composed of dark green sand." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 30, pl. 1, fig. 1; pl. 37, fig. 9, 1924. San Francisco Bay to San Diego, California. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 128, pl. 1, fig. 13; pl. 14, fig. 3, 1931. Halfmoon Bay, California, Recent. Also cited from late Miocene to Recent. — Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 68, pl. 32, figs. d, e, 1968. San Diego area, Pleistocene. Not *Yoldia cooperii* Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 31 (in part), 1866. "Miocene, south of Martinez, and north of Walnut Creek, Contra Costa County." Referred to *Yoldia cooperii supramonteyensis* Arnold, by Stewart, Acad. Nat. Sci. Philadelphia, Spec. Paper No. 3, p. 63, pl. 15, fig. 2, 1930.

Type specimen. — No. 30, 613, Univ. of California

Department of Paleontology, Invertebrate Type Collection.

Type locality. — "A single left valve was found on the beach at Santa Cruz, Cal., by Dr. Cooper."

Range. — Middle Miocene ("cf.") to Recent. Recent from off Point Reyes, California, to Todos Santos Bay, Lower California, Mexico, in 9 to 124 meters (5 to 68 fathoms), usually in sand.

Occurrence in San Diego Fm. — L.A.M. 323.

Original description: Shell thin, somewhat compressed, very inequilateral, beaks placed about a third of the length from the anterior end, minute; anterior end narrow, sub-acuminate, posterior end broadly rounded; base most prominent just posterior to the middle of the shell; surface sculptured by numerous small concentric ribs, rarely dichotomous or anastomosing on the widest part of the shell; these ribs are flat and abruptly truncated on the side nearest the beak, giving the surface, under a glass, the appearance of an overlapping. Epidermis shining, olivaceous; internally a bluish white; muscular scars large, the anterior triangular, posterior a third the largest, broadly suboval. Long. 1.25, lat. 2.6, alt. .25 [inches]. (Gabb.) [A description also was given in the Latin language.]

Remarks. — Fragments of two fossil valves retaining the umbonal area, ligamental pit and several teeth, are present in the collection. The largest fragment is 4.8 mm long. These fragments agree well with the corresponding portions of the shell of *Yoldia cooperi*.

The large ligamental pit and hinge teeth evidently are part of large valves. The largest Recent specimen, a right valve, in the collections of the California Academy of Sciences, collected by Henry Hemphill at San Diego, is 52.6 mm long and 25.5 mm high. A large left valve from Loc. 92 (CAS), collected by Bruce Martin from beds of late Pleistocene age on Deadman Island, San Pedro, California, is 55 mm long and 28 mm high.

Compared to *Yoldia oregonensis* Conrad (62), described from strata believed to be of Oligocene age, the beaks of *Y. cooperi* are more posteriorly situated and the rostrum is shorter.

Yoldia supramontereyensis Arnold (63), described from beds of late Miocene age in California, is less attenuated posteriorly than typical *Y. cooperi*.

Yoldia cooperi tenuissima Clark (64), described from beds of late Oligocene or early Miocene age in central California, has the beak more anteriorly situated and a longer rostrum than *Y. cooperi*.

A fossil form described as *Yoldia cooperi ochotensis* Khomenko (65), from beds of Pliocene age on Sakhalin Island in the North Pacific, is referable to the subgenus *Cnestrium* Dall. Illustrations of it reveal the presence of oblique lines crossing the concentric sculpture. It obviously is not related to *Y. cooperi*. Kamada (66) pointed out that this also was true of specimens referred to *Y. c. ochotensis* by Otuka (67).

Another fossil form, "*Yoldia cooperi* Gabb var. *kovatschensis*" Slodkewitsch (68), was described from beds questionably of Oligocene age on Kamtschatka. The concentric sculpture was described as consisting only of fine concentric lines but lacking concentric ridges such as are present on *Y. cooperi*.

SUBCLASS PTERIOMOPHIA BEURLÉN
ORDER EUTAXODONTIDA GROBBEN
SUPERFAMILY ARCACEA OKEN (69)
FAMILY ARCIDAE OKEN (70)

Shell equivalve, or nearly so, trapezoidal, subquadrate, or rounded, with the posterior side equal or longer; ligament exterior, attached to an area beneath and often on both sides of the beak; hinge with taxodont teeth in two similar series meeting below the beaks, the long dimension of the individual comb-like teeth approximately at right angles to the dorsal margin of the valves; pallial line generally distinct, without a sinus; muscle impressions nearly equal. (Grant and Gale, 1931). Middle Jurassic (71) to Recent. Recent, world-wide.

Abundant in shallow, tropic, subtropic and warm temperate marine waters, but two genera, *Senila* Gray and *Scaphula* Benson, occur in brackish water, the latter also occurs in fresh water. *Batharca* occurs at depths of 3658 meters (2000 fathoms).

Remarks. — Reinhart (72) published a very useful monograph of the fossil west American species of this family. The Recent species have been discussed by Maury (73) and by Hertlein and Strong (74), and a publication by Olsson (75) contains a discussion of the members of the Arcidae living in the tropical waters of Peru and Ecuador. A recent paper by Noda deals with the Cenozoic Arcidae of Japan (Sci. Repts. Tohoku Univ., Sendai, Second Ser. (Geol.), Vol. 38, No. 1, pp. 1-130, pls. 1-14, figs. 1-16 in text, October 10, 1966). The anatomy of the Arcidae is discussed in a paper by Heath (76).

Eleven species and subspecies of the Arcidae were recorded by Reinhart from strata of Pliocene age in California. Four species and subspecies occur in the San Diego Formation.

Key to Genera and Subgenera of Arcidae

- A. Ligamental area extremely wide and almost flat *Arca*
- B. Ligamental area narrow and V-shaped
 - a. Inner margin strongly crenulated; ribs narrow, strap-like *Anadara*
 - aa. Inner margin not crenulated or only faintly so; ribs thread-like, usually alternating in size
 - b. Ligamental grooves all extending anterior to the beak; hinge with a continuous series of teeth *Barbatia*
 - bb. Ligamental grooves confined chiefly posterior to the beak; hinge of adult with an edentulous gape centrally *Fugleria*

GENUS *ARCA* LINNAEUS

Arca Linnaeus, Syst. Nat., ed. 10, p. 693, 1758. Fifteen species cited including *Arca noac*. — Reinhart, Bull. Mus. Roy. d'Hist. Nat. Belgique, Tome 11, No. 13, p. 14, 1935. "Type species; *Arca noac* Linné. . . ."

Navicula Blainville, Dict. Sci. Nat., Vol. 34, p. 319, 1825.

Type (by monotypy): *Arca noae* Linnaeus. — Iredale, Brit. Mus. (Nat. Hist.), Great Barrier Reef Exped. 1928-29. Sci. Repts., Vol. 5, No. 6, Moll. Pt. 1, p. 291, 1939. "Haplotype: *Arca noae* Linné."

Not *Navicula* Bory de Saint-Vincent, Dict. Class. Hist. Nat. Paris, Vol. 2, p. 128, 1822. [Diatomacea.]

Byssosarca Swainson, Zool. Illustr., Ser. 2, Vol. 3, expl. to pl. 118, 1832-1833, issued March, 1833. Species cited: "*Byssosarca zebra*" from the "West Indies" and "Jamaica", and "*B. noae*." — Sowerby, Proc. Zool. Soc. London for 1833, p. 16, issued May 17, 1833. — Herrmannsen, Ind. Gen. Malacozoor, Vol. 1, p. 149, 1846. "Typus: *Arca Noae* Linn."

Type species (by designation of Internatl. Comm. Zool. Nomencl., Opinion 189, signed October 5, 1944, published July 26, 1945). — *Arca noae* Linnaeus, 1758 [Syst. Nat., ed. 10, p. 693, 1758. "Habitat in M. rubro, Mediterraneo, Indico." Ref. to "List. conch. 3. B.s.6.c.1. t.5."; "Rumph. mus. t. 44.f.p."; "Gault. test. t.87.f.H.I.", and others. Illustrated by Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Tome 2, Fasc. 5 (Pelecypoda, Fasc. 18), p. 174, pl. 30, figs. 1-5, (6, var.), 1891. Mediterranean region, Atlantic to Senegal and the Canary Islands. For a discussion of this species see Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 143-144, 1952].

Range. — Middle Jurassic to Recent. Reported from Eocene to Recent in western North America. Recent, worldwide in tropical and subtropical marine waters, but some species ranging into the boreal zone. Mostly in intertidal zone to shallow neritic zone, occasionally to a depth of 146 meters (80 fathoms) or deeper. *Arca tetragona* Poli reported from a depth of 2655 meters (1457 fathoms).

Description. — The Arcas typified by *A. noae* are equivalve, inequilateral transversely elongate, rudely quadrate, or oval, commonly irregular in outline, and gaping anteriorly. The beaks are prominent, placed well forward and separated by a wide cardinal area scarred with oblique discontinuous cartilage grooves. The radials that adorn the outer surface differ in prominence and spacing on different parts of the shell. The hinge is straight; the teeth are numerous, short, subequal, and transverse. The adductor impressions are distinct, the pallial line is simple, and the inner margins are smooth or feebly crenate at the extreme edge in harmony with the radial ornamentation of the exterior. (Gardner, U. S. G. S., Prof. Paper 199, p. 22, 1948.)

Remarks: *Arca s. s.* is here recorded for the first time from the San Diego formation.

Reinhart cited seven species from the Cenozoic of western North America. Three species now live in tropical and subtropical waters of the western Americas. One of these, *A. fernandezensis* Hertlein and Strong, was originally described from Juan Fernandez Island off Chile in 34° South Latitude. *Arca pacifica* Sowerby ranges north to the head of the Gulf of California and to Scammon Lagoon, 27° 54' North Latitude, on the Pacific Coast of Lower California. In the Japan Sea, one species of *Arca s. s.* ranges to 45° North Latitude.

SUBGENUS *ARCA S. S.*

Arca (Arca) sisquocensis Reinhart
Plate 27, Figures 26, 27, 31-33

Arca (Arca) sisquocensis Reinhart, Jour. Paleo., Vol. 11, No. 3, p. 182, pl. 28, figs. 1-3, April, 1937. — Reinhart, Geol. Soc. Amer., Spec. Papers No. 47, p. 25, pl. 2, figs. (holotype), 10, 11, 12, 1943. "From the Careaga formation, Pliocene, of Fugler Point, near Santa Maria, Calif." — Hall, Jour. Paleo., Vol. 38, No. 1, p. 88 (in text), pl. 22, figs. 1 and 2, 1964. "Santa Barbara Formation, Packards Hill, Santa Barbara, California. Plio-Pleistocene."

Arca sisquocensis Reinhart, Vedder, in Vedder and Norris, U. S. G. S., Prof. Paper 369, p. 46, 1963. Terrace on San Nicolas Island, "Pleistocene. — Valentine and Lipps, Jour. Paleo., Vol. 37, No. 6, pp. 1294, 1299, 1963. 250-foot terrace on central Anacapa Island, "Early Pleistocene (or late Pliocene) age".

Type specimen. — No. 1382, California Institute of Technology.

Type locality. — "Pliocene asphalt beds of Fugler Point, 7 1/2 miles southeast of Santa Maria, Santa Barbara County, California (type)." [Cebada member of the Careaga Formation (Woodring, 1950).]

Range. — Middle Pliocene to early Pleistocene.

Occurrence in San Diego Fm. — L.A.M. 305, 305A.

Original description (of holotype). — Small, well-preserved right valve, elongate in outline, moderately inflated, slightly inequilateral.

Profile. — Anterior margin evenly rounded; ventral margin straight, nearly parallel to hinge margin; posterior margin straight, forming acute angle where it intersects ventral margin, and meeting hinge margin at angle of 45°. Umbo located just anterior to center of shell, projecting slightly. An unusually sharp ridge extends from umbo to posterior ventral corner; above this ridge, shell is concave. A faint medial sulcus extends from byssal gape, upward a short distance toward umbo.

Sculpture. — About 40 radial ribs, with occasional small inter-ribs. On posterior slope, ribs are large and dichotomizing; elsewhere, simple and ornamented with closely-spaced nodes. The five anterior-most ribs are as large as the posterior ones, but do not dichotomize. Concentric growth-lines are not prominent, but two distinct concentric bands may be distinguished, and several less distinct ones. Ligamental area narrow in front of umbo, wide behind, these becoming noticeably excavated. About two right-angled, chevron-shaped grooves directly beneath umbo. Hinge straight, narrow, only slightly wider at extremities than at center; thirty-two teeth, small and granular at center, increasing regularly in size toward extremities of hinge; teeth converge ventrally, the anterior more sharply than the posterior. Muscle scars distinct, notable because of a raised flange bordering inner side of each scar, the posterior flange being the larger. (Such raised flanges are ordinarily not present on *Arca s. s.*, although they are present in *Striarca*, and in *Noetia* and *Trigonarca* a flange is developed on the inner side of the posterior muscle scar; these flanges are therefore of interest, and have been previously mentioned) (5) [footnote]. Inner margin of shell crenulated, especially at extremities. Narrow hyssal gape near center. Pallial line simple; within this line, inner side of shell faintly striated by radial lines.

Dimensions of holotype (in mm): Length 15.4; height 7.6; convexity (right valve) 4. (Reinhart.)

Remarks. — 20 specimens of this species vary in preservation, and in size from 5 to 24 mm long. The notable difference observed in this series, which varies from Reinhart's description of the type specimen, is the presence of about seven ligamental grooves on the cardinal area of the largest specimen (a fragment which represents an individual probably 30 mm long). This larger number of grooves is, no doubt, a result of the greater size of this shell in comparison to the holotype which is 15.4 mm long.

Woodring (77) pointed out that "Adult shells of *A. sisquocensis* have a wider posterior slope than that of *A. kobeltiana*, the posterior ridge being more strongly curved." An earlier name for *Arca kobeltiana* Pilsbry (78) is *A. boucardi* Jousseaume (79), a species reported to range from early Miocene to Recent in Japan.

Arca (Arca) leptogrammica Hall (80), described from strata of late Miocene age in the Nipomo quadrangle, San Luis Obispo Co., California, was compared by its author with *A. sisquocensis* and *A. boucardi*. The type of *A. leptogrammica* is 56 mm long. It was described as much larger than *A. sisquocensis* and with finer radial ribs which are not beaded.

GENUS ANADARA GRAY

Anadara Gray, Proc. Zool. Soc. London for 1847, p. 198 (issued November, 1847). "*Arca antiquata*" indicated as type. — Cox, Rept. Palaeo. Zanzibar Protectorate, p. 34, September, 1927. "Type: — *A. antiquata* (Linne); original designation."

Diluvarca Woodring, Carnegie Inst. Washington, Publ. 366, p. 40, May 20, 1925. "Type. — *Arca diluvii* Lamarck." — Woodring, Carnegie Inst. Washington, Publ. 385, p. 18, footnote, 1928. "*Diluvarca* is suppressed as a synonym of *Anadara*."

Type species (by original designation): *Arca antiquata* Linnaeus [Syst. Nat., ed. 10, p. 694, 1758. "Habitat in O. Americano." Illustrated by Hanley, Ipsa Linnaei Conchylia, pl. 4, fig. 3, 1855, and by Woodring, Carnegie Inst. Washington, Publ. 366, pl. 4, figs. 1, 2, 1925. See discussion by Dodge (Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 149, 1952) who considers Reeve's figure of *Arca maculosa* (Conch. Icon., Vol. 2, *Arca*, sp. 24, pl. 4, fig. 24, 1844) to represent the true *A. antiquata* of Linnaeus].

Range. — ?Late Oligocene (81) to Recent. Recent in western North America from Cedros Island, Lower California, Mexico, to the Gulf of California and south to Paita, Peru, littoral zone to 128 meters (70 fathoms), but usually in less than 75 meters (41 fathoms).

Description. — Shell thick, equivalve, ovate or trapezoidal, gibbous, more or less inequilateral; valves closed along ventral margin; cardinal area of moderate width, with the greater part of its surface covered by the ligament, and usually, although not invariably, ornamented with a few chevron-shaped grooves; sculpture consisting of strong, narrow, flattened ribs separated by squarely-channelled interspaces; internal margins crenulated according to the external ribbing; hinge-teeth obscurely discontinuous just behind the umbones, those belonging to the anterior series being slightly longer than those of the

posterior series where the two series meet; central teeth small, perpendicular to the hinge-margin, the teeth increasing in length laterally and becoming slightly oblique at each extremity. (Cox, 1927.)

Remarks. — *Anadara* has been confused with *Arca* by some workers, but definite designation of *Arca noae* Linnaeus as the type species of *Arca* clearly places *Anadara* in a different group.

Diluvarca described by Woodring was later suppressed by its author and considered to be referable to *Anadara*. Olsson (1961, p. 87), more recently, doubted that *Anadara* s. s. is represented in west American waters. He assigned six species living in the eastern Pacific to *Diluvarca* which he placed as a subgenus of *Anadara*.

Nineteen species and subspecies originally described from the late Cenozoic of western North America were referred to *Anadara* by Reinhart. A huge specimen 90 mm long was reported by Mandra (82) from strata of late Cenozoic age in Salinas Valley, California.

Four species of *Anadara* are known from strata of Pliocene age in California. One species and a subspecies occur in the San Diego Formation.

Iwasaki (83) recently discussed the species of *Anadara* of Tertiary age in Japan.

Key to Species of *Anadara* (84)

- A. Viewed from above (both valves together),
anterior end broadly rounded *calcareo*
- B. Viewed from above (both valves together),
anterior end sharply pointed *trilineata*

Anadara trilineata Conrad Plate 28, Figures 1, 2, 3, 4, 6

Arca trilineata Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 8, No. 6, p. 314, dated December, 1856, but apparently issued subsequent to April 25, 1857. — Conrad, U. S. Pac. Railroad Expl., Vol. 6, Pt. 2, No. 2, p. 70, pl. 2, fig. 9, 1857. [Original reference and locality cited.] "Tertiary." Illustration reproduced by Slodkewitch, Paleo. of USSR, Vol. 10, Pt. 3, Fasc. 19, Tertiary Pelecypoda from the Far East, Pt. 2, Acad. Sci. USSR Press (Moscow; Leningrad), pl. 11, fig. 5, see pp. 105, 214, 1938. — Arnold, U. S. G. S., Prof. Paper 47, p. 100, 1906. "Pacific Beach, near San Diego." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 170, 1912. "San Diego-Purisima." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 150, 1919. "San Diego." — "cf." Dall, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 62, 1919. "lower member of . . . section" in well in "South Las Choyas Valley." — Carson, Pan-Amer. Geol., Vol. 43, No. 4, p. 268, 1925. "San Diego fauna." — Hertlein and Grant, Calif. State Jour. Mines Geol., Rept. State Mineral., 35, p. 69, 1939. "higher beds" in section of Pliocene strata at Pacific Beach. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Refers to Dall's record (1874) of *Arca microdonta* from well at San Diego. — Hertlein and Grant, Calif. State Div. Mines, Bull. 170, chapter 2, p. 60, 1955. "San Diego formation." *Arca microdonta* Conrad, Dall, Proc. Calif. Acad. Sci.,

- Vol. 5, p. 297, 1874. "well at San Diego." "Pliocene." — Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 28, 1878. "Well" at San Diego and "well-digging in stratum B²." — Cooper, California State Min. Bur. Seventh Ann. Rept. State Mineral., Vol. 7, p. 229, 1888. "San Diego well." — Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 85, 1889. Dall's record (1874) cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) referred to *Arca trilineata*.
- Not *Arca microdonta* Conrad, House Doc. 129, Projected Vol. 3, 33rd Congress, 1st session, p. 13, 1855. "Locality. — Tulare Valley ? Miocene."
- Arca sulcicosta* Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 31, pl. 9, figs. 53, 53a, 1866. "Found with *Dosinia Staleyi*, on Mark West Creek, Sonoma County, by Mr. V. S. Staley." [Pliocene.]
- Not *Arca sulcicosta* Nyst, 1836.
- Arca schizotoma* Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 659, April, 1898. New name for *Arca sulcicosta* Gabb, 1866. Not *Arca sulcicosta* Nyst, 1836. — Dall, U. S. G. S., Prof. Paper 59, p. 111, 1909. "San Diego well." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 170, 1912. "San Diego-Purisima."
- Arca (Scapharca) trilineata* Conrad, Dall, U. S. G. S., Prof. Paper No. 59, pp. 110-111, 1909. "Pliocene of San Diego well (city park), H. Hemphill, U. S. Nat. Mus. 7934; also Homer Hamlin."
- Arca (Arca) trilineata* Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 139, pl. 2, fig. 1 (Shuman's Cut), fig. 4 (Elsmere Canyon), 1931. P. 140, "Pliocene of San Diego well (Hemphill and Hamlin, *fide* Dall, 1909)."
- Arca (Anadara) trilineata* Conrad, Hertlein and Grant, Calif. State Div. Mines, Calif. Jour. Min. Geol., Rept. 35 Calif. State Mineral., p. 70, 1939. "San Diego well." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 57, 1944. "Pliocene strata at Pacific Beach." — Glibert and Van de Poel, Mém. Inst. Roy. Sci. Nat. Belgique, Deuxième Sér., Fasc. 77, p. 55, 1965. Reynard Way, San Diego, Pliocene (as *Anadara* (s. s.) *trilineata*).
- Anadara trilineata* Conrad, Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, 1941. "Strata at Pacific Beach." — Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. San Diego Formation at Pacific Beach. Also Niguel Formation and others. — Milow and Ennis, 57th Ann. Mtg. Cordilleran Sec., Geol. Soc. Amer., Field Trip Guidebook, San Diego Co., p. 28, 1961. "San Diego formation".
- Anadara (Anadara) trilineata* subsp. *trilineata* Conrad, Reinhart, Geol. Soc. Amer., Spec. Papers No. 47, p. 57, pl. 5, fig. 9; pl. 6, figs. 1-3, 5, 7; pl. 7, fig. 1, 1943. P. 59, "Pliocene, San Diego well, Balboa Park, San Diego."
- Anadara (Anadara) trilineata* Conrad, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 36, pl. 16, figs. a, b, 1968. Reynard Way, San Diego, Pliocene. Also Pliocene of California, Oregon, and Washington.
- Type specimen. — Location unknown to the present authors. No record of the holotype at the U. S. National Museum (see Reinhart, p. 58).
- Type locality. — "Occurs with the preceding" [which refers to *Arca canalis* Conrad with the locality "Santa Barbara, Cal." "Middle Tertiary."].
- Range: Late Miocene (Cierbo sandstone); early and middle Pliocene in California, Oregon and Washington.
- Occurrence in San Diego Fm. — C.A.S. 1129, 1401, 1404, 1415, 1418, 12107, 28885, 28889, 28892, 28893, 36384. L.A.M. 104, 107, 302, 305, 305A, 305B. S.D. 29, 34, 38, 79, 80, 81, 331, 365, 416, 417, 2954. U.C. A-8333. U.C.L.A. 294, 295, 302, 310, 312, 2359.
- Original description. — Trapezoidal, somewhat produced, inequilateral, ventricose; ribs 22-24, scarcely prominent, square, wider than the intervening spaces, ornamented with three impressed or four raised lines; disks concentrically wrinkled; summits prominent; beaks approximate. Length 3 inches. (Conrad.)
- Remarks. — There is uncertainty concerning the locality from which the type of *Arca trilineata* Conrad originally came, and the whereabouts of the type specimen is unknown. It is generally accepted that this is the well known elongately subtrapezoidal species which occurs as a fossil in strata of Pliocene age in California. Woodring (85) gave an adequate discussion of the problem of the type locality and the identification of this species.
- We have had a large number of specimens available for study including several hundred valves varying in length from 5 mm to 68 mm, which were collected by G. P. Kanakoff at Locs. 305 and 305A (LAM) near the Mexican Boundary. The umbos of many of the valves have been bored by a gastropod. A valve from Loc. 305B (LAM) is 79 mm long.
- These specimens vary somewhat in proportion of length to height but all are decidedly longer than high. The number of ribs varies, usually from 25 to 28. This is in agreement with Addicott's observations on specimens of this species from the Merced formation in northern Santa Clara County, California. He stated (86) that most of those have 26, some with 24, and some with 28 ribs. The ribs on the anterior half of the shell are often deeply sulcated or almost bifid, those on the posterior half usually bear two, three, or occasionally four shallow grooves. The ribs usually begin to develop a medial sulcation after the shell attains a height of about 8 to 10 mm, occasionally earlier. The ribs are usually at least partially beaded.
- An impression of the anterior end of a large *Anadara*, 73 mm long, collected by G. P. Kanakoff at Loc. 107 (LAM), end of Arroyo Drive in San Diego, is probably referable to *A. trilineata*. The end view from above is not broadly rounded as is that of *A. t. calcarata*.
- Specimens from the San Diego well in the collections of the California Academy of Sciences labelled "*Arca microdonta* Conrad" by Henry Hemphill, are definitely referable to *A. trilineata* and *A. trilineata calcarata*. Possibly the unfigured fossils recorded by Whiteaves (87) under the name of *Arca microdonta* from beds of late Tertiary age on Graham Island, Queen Charlotte Islands, Canada, is referable to *A. trilineata*. Woodring (88) and Reinhart (1943, pp. 46-47, p. 6, figs. 9, 10) have given good discussions of *Arca microdonta* Conrad (89), a species originally reported to have been found in "Tulare Valley?." Blake who sent the fossil to Conrad cited the locality as "the hills of the Coast Mountains near the Tulares." Woodring (1938, p. 31; 1941, p. 89) sug-

gested that this description might be applied to Kettleman Hills but he believed it possible that the specimens were collected by Blake on the Atlantic coast of Panama. The type specimen, of which we have seen a cast, bears a close resemblance to *A. nobilis* Röding in Bolten (*A. deshayesii* Hanley), a Recent Floridan and West Indian species. More recently, Weaver (90) cited "*Anadara? microdonta* (Conrad)" from the Temblor Formation, middle Miocene, Santa Monica, California. The illustrations closely resemble those of *Anadara topangensis* Reinhart (1943, p. 10, figs. 13, 14) from the Topanga Formation, Miocene, Santa Monica Mountains, Los Angeles Co., California.

Reinhart (1943, p. 58) doubted the record of the occurrence of *Anadara trilineata* in the Empire Formation which is of Pliocene age at Coos Bay, Oregon. Specimens from those strata which we have seen appear to be identical with *A. trilineata* except that they have about 29 radial ribs. Reinhart did not recognize specimens referable to *A. trilineata* in beds of Miocene age, but Hall (91) identified one specimen with this species from the Cierbo Sandstone in the La Costa Valley quadrangle in west central California and Stanton (Jour. Paleo., Vol. 40, No. 1, p. 23, 1966) reported this species from the Castaic Formation.

The fewer ribs as well as their beaded ornamentation and the slender umbos are features which serve to separate *Anadara trilineata* from two somewhat similar Miocene species, *A. devincta* Conrad (92) and *A. montereyana* Osmond (93). The less convex valves and more sharply projecting umbos as well as the usually beaded character of the ribs are shell characters differing from those of *A. devincta montesanoana* Etherington (94).

Species from the Miocene and Pliocene of Japan have been recorded under the name of *Arca trilineata* but as pointed out by Reinhart (1943, pp. 59-60) those fossils possess more numerous radial ribs (32-33), and later they were referred to other species by Hatai and Nisiyama (95).

Anadara amacula Yokoyama (96) from the late Tertiary of Japan is a similar species. Kanno (97) included eight species from Japan in the *A. trilineata* group, occurring in strata from late Oligocene to Pliocene age.

Slodkewitsch (98) cited a species from the Pliocene Kavrana series in Kamtschatka under the name of *A. trilineata* but those records cannot be referred with certainty to that species. Krishtofovich (99) mentioned a fossil form which he cited as a subspecies of *A. trilineata* with 29 to 34 ribs occurring in strata of early Pliocene age in Sakhalin Island.

Anadara trilineata calcarca Grant and Gale
Plate 28, Figures 5, 7-10

Arca (Arca) trilineata Conrad variety *calcarca* Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 140, pl. 2, figs. 6a, 6b, November 3, 1931. — Keen and Benton, Geol. Soc. Amer., Spec. Papers, No. 56, p. 26, 1944. Records of Grant and Gale cited.

Arca (Anadara) trilineata subsp. *calcarca* Grant and Gale, Reinhart, Geol. Soc. Amer., Spec. Papers No. 47, p. 61, pl. 9, figs. 6, 7, 8, 1943. "Pliocene of San Diego, Calif." Type locality also cited.

Arca trilineata calcarca Grant and Gale, Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1,

p. 59, 1944. "Near the Mexican Boundary about three-quarters of a mile from the sea."

Anadara trilineata Grant and Gale, Korobkov, Metodicheskoe Rukovodstvo po Tretichnym Molluskam Plastinchatozhabernye [Lamellibranchiata], (Leningrad), pl. 55, fig. 4, 1954. Copy of pl. 2, fig. 6a of Grant and Gale, 1931.

Anadara trilineata calcarca Grant and Gale, Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. San Diego Formation. Also Niguel Formation.

Type specimen. — Holotype No. 436, Department of Geology, Stanford University.

Type locality. — "San Diego well; Pliocene."

Range. — Middle Pliocene (100) of southern California.

Occurrence in San Diego Fm. — Well at San Diego (*Arca trilineata* Conrad in part, of Dall). C.A.S. 1401, 1418, 12107.

Original description. — Shell like that of typical *Arca trilineata* Conrad, but larger, much thicker, and with more numerous cardinal grooves. (Grant and Gale.)

Remarks. — Reinhart (1943, p. 61) has added the following pertinent remarks concerning this form: "In addition, when viewed from above, the anterior end of the shell of *A. trilineata calcarca* is bluntly pointed, differing from typical *A. trilineata*, which is sharply pointed. This blunt point was acquired at a late stage in the growth of the shell of *A. trilineata calcarca* as shown by the growth lines."

The differences between this subspecies and typical *Anadara trilineata* are mostly the result of the large size, thick shell and corresponding convexity of the valves. Reinhart pointed out that several normal but rather large specimens of *A. trilineata* s. s. were found at the type locality of the subspecies *A. t. calcarca*.

About a dozen large specimens, mostly single valves, are present in the collections at hand. They are characteristic of the subspecies and possess about 26-27 radial, sulcated ribs and about 6 or 7 chevron-shaped ligamental grooves. The largest valve, the anterior end incomplete, from Loc. 1401 (CAS), south slope of Mount Soledad, is 86.8 mm long, 70.8 mm high, convexity (one valve), 30.8 mm. One from the San Diego well measures, length 78 mm, height 66.5 mm, convexity (one valve), 24 mm.

Three valves, the largest one 83 mm long, from Loc. 2359 (UCLA), south slope of Mount Soledad, cited among the locality records of *Anadara trilineata*, clearly show the first stages of the rounding of the anterior end which characterizes *A. t. calcarca*. However, these valves have not developed the extreme rounded anterior end typical of *A. t. calcarca*. A specimen 59 mm long, typical of *A. trilineata*, was collected at the same locality.

Grant and Gale recorded the subspecies *Anadara trilineata calcarca* from strata of mid-Pliocene age in the Santa Clara Valley in southern California. Richmond (101) later reported its occurrence on Burrue Point, northwestern Santa Ana Mountains, Orange County, California, about 50 feet above the base of the "Repetto (?) Formation."

[*Anadara trilineata canalis* Conrad]

Arca canalis Conrad, Proc. Acad. Nat. Sci. Philadelphia,

Vol. 8, No. 6, p. 314, dated December, 1856, but apparently issued subsequent to April 25, 1857. "Santa Barbara, Cal." "Middle Tertiary." — Conrad, Pac. Rail Road Expl., Vol. 6, Geol. Rept. 2, p. 70, pl. 2, fig. 8, 1857. Same locality as originally cited. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 170, 1912. "San Diego-Purisima." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 150, 1919. "San Diego." "Pliocene."

Anadara (Anadara) trilineata subsp. *canalis* Conrad, Reinhart, Geol. Soc. Amer. Spec. Papers No. 47, p. 60, pl. 7, figs. 3, 4, 1943. "Purisima formation. Pliocene of Capitola, Santa Cruz Co., Calif." "Known definitely only from the Pliocene of California."

Remarks. — The only records of the occurrence of this subspecies in the San Diego Formation are those of J. P. Smith. No specimens of this form were recognized by us in any of the collections from the San Diego Formation.

The subspecies *Anadara trilineata canalis* differs from typical *A. trilineata* in that the length and height are nearly equal. Reinhart (1943, p. 60) has given a good discussion of this form. According to him, *A. t. canalis* occurs with typical *A. trilineata* at some localities but that at Capitola and in Kettleman Hills, California, typical *A. trilineata* apparently ranges somewhat higher stratigraphically than does the form *canalis*.

GENUS BARBATIA GRAY

Barbatia Gray, Synopsis of the Contents of the British Museum, ed. 42, p. 151, 1840; ed. 44, p. 81, 1842. [No species cited. See Iredale, Proc. Malacol. Soc. London, Vol. 10, Pt. 4, pp. 299, 303, 1913.] — Gray, Proc. Zool. Soc. London for 1847, p. 197. Type indicated as "*A. barbata*." — Reinhart, Bull. Mus. Roy. d'Hist. Nat. Belgique, Vol. 11, No. 13, p. 20, August, 1935. Type designated by Gray.

Type species (by subsequent designation, Gray, 1847). — *Arca barbata* Linnaeus [Syst. Nat., ed. 10, p. 693, 1758. "Habitat in M. Mediterraneo." Illustrated by Reeve, Conch. Icon., Vol. 2, *Arca*, sp. 83, pl. 13, fig. 83, 1844. "Hab. Mediterranean and other seas of Europe." — Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Tome 2, Fasc. 5 (Pelecypoda, Fasc. 18), p. 182, pl. 32, figs. 1-5 (typical), 6, 7, 8 (var.), 1891. Mediterranean Sea to Cape Verde Islands. For a discussion of this species see Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 144-145, 1952.]

Range. — Late Jurassic (Kimmeridgian (102) to Recent. Recent world-wide in tropical and subtropical waters, some members ranging into the warm temperate zone. From the littoral zone to 183 meters (100 fathoms). Occasionally deeper.

Description. — Shell of moderate size, not very thick, inequilateral, elongately elliptical to subquadrate in outline, a slight byssal gape at the ventral margin, beaks anterior to center or subcentral; cardinal margin narrow; ligament multivincular; sculpture consisting of radial (often somewhat irregular) threads crossed by concentric striae; exterior with a hairy (bearded) periostracum; teeth increase in obliquity from the center to the ends of the hinge; inner margin crenated or smooth.

Remarks. — *Barbata* differs from *Arca s. s.*, type

Arca noae Linnaeus, in the usually rounded umbonal angle, in the prosogyral beaks, the narrower ligamental area, the more oblique teeth, and the slighter byssal gape.

Cucullaearca Conrad, according to Reinhart (103) is "characterized by a large byssal gape, a wide, grooved ligamental area which usually separates the anterior teeth widely from the posterior ones, a widened posterior end, and a fairly heavy shell."

Abarbatia Dall, Bartsch and Rehder (104), based on a Recent Hawaiian species, was described as "Like *Barbatia* in ligamental and hinge characters, but differing from it in not having the periostracum cut into fringes but smooth."

SUBGENUS FUGLERIA REINHART

Fugleria Reinhart, Jour. Paleo., Vol. 11, No. 3, p. 184, April, 1937.

Type species (by original designation). — "*Barbatia (Fugleria) pseudoillota* Reinhart, n. sp., from the Pliocene of Fugler Point." Pl. 28, figs. 6, 9, 10.

Range. — Middle Pliocene to Recent. Recent in tropical and subtropical waters.

Description. — The ligament of *Fugleria* is similar to that of *Acar*, being confined chiefly to the posterior of the beaks, but the hinge is different, the posterior teeth of *Fugleria* being only feebly developed or even totally absent, as in the type species. *Fugleria*, in addition, lacks the elevated scars and reticulate sculpture of *Acar*. (Reinhart, 1937).

Remarks. — This subgenus is here recorded from the San Diego Formation for the first time.

The ligamental grooves on *Barbarca* Dall, Bartsch, and Rehder (105), based upon a Hawaiian species, are somewhat similar to those on *Fugleria* and the hinge has a subumbonal edentulous area. Whether this Hawaiian group is closely related to *Fugleria* is unknown.

Didimacar Iredale (106) also bears a general resemblance to *Fugleria* in outline, ribbing, and ligamentary grooves. It differs in that the hinge does not have an edentulous area under the beaks, the muscle impressions lack flanges and the periostracum is described as thin and dark.

Barbatia (Fugleria) illota Sowerby
Plate 27, Figures 35, 36, 38, 39, 40

Byssosarca illota Sowerby, Proc. Zool. Soc. London for 1833, p. 18, issued May 17, 1833.

Arca illota Sowerby, Reeve, Conch. Icon., Vol. 2, *Arca*, sp. 78, pl. 12, fig. 78, 1844. "Hab. Gulf of Nicoya, Central America (found under stones); Cuming."

Arca (Byssosarca) tabogensis C. B. Adams, Ann. Lyceum Nat. Hist. New York, Vol. 5, pp. 486, 545 (separate, pp. 263, 321), July, 1852. "Habitat. — Taboga and Panama; C.B.A.!" "Under stones at low water." — Turner, Occas. Papers on Moll., Dept. Moll., Harvard Univ., Vol. 2, No. 20, p. 90, pl. 19, figs. 7, 8, 1956. Original record cited.

Barbatia (Acar) illota Sowerby, Maury, Palaeontogr. Americana, Vol. 1, No. 4, p. 182 (20), pl. 30 (2), figs. 8, 14, 1922. "Panama (Newcomb coll.); Bucarn [Bucaru], Los Santos Province; and the northeast point of Viveros Island, Islas de las Perlas (Olsson coll.)." —

Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 54, pl. 1, fig. 6 1950. Cited from San Marcos Island, and Santa Inez Bay, Lower California, Pleistocene.

Barbatia (Fugleria) illota Sowerby, Rost, Allan Hancock Pac. Exped., Vol. 20, No. 2, p. 187, pl. 11, figs. 6-8, text figs. 83a-c, 1955. "Isla Angel de la Guarda, Gulf of California, to Lobitos, Peru"; intertidal zone attached to rocks, to a depth of 40 fathoms.

Fugleria illota Sowerby, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 83, pl. 6, figs. 1-1b, 1961. Gulf of California to northern Peru.

Type specimen. — British Museum (Natural History)?

Type locality. — "Hab in América Centrali." "Found under stones in the Gulf of Nocoioy." [Costa Rica.]

Range. — Middle Pliocene to Recent. Recent from Punta Peñasco, Sonora, Mexico, to Lobitos, Peru, and the Galápagos Islands, from intertidal zone, attached to rocks, to a depth of 73 meters (40 fathoms).

Occurrence in San Diego Fm. — C.A.S. 28893. L.A.M. 305, 305A.

Original description. — Byss. testâ ovatâ, albâ, radiatim costatâ, costis numerosis, decussatis; epidermide fuscâ, foliaceâ indutâ; latere antico brevior, rotundato, postico declivi; areâ ligamenti angustâ, brevi: long. 1.5, lat. 0.75, alt. 1, poll. (Sowerby.)

Remarks. — More than 100 specimens of a small arcid collected by Kanakoff at Loc. 305 (LAM) are here assigned to *Barbatia (Fugleria) illota*. These vary in length from 3 to 20 mm. The shape is somewhat variable. On small specimens teeth are present along the entire hinge but on large specimens the posterior portion of the hinge is devoid of teeth except for four or five at the end. As mentioned by Rost the teeth are striated. The ligamental grooves on small specimens are posterior to the beak, but larger specimens (35 mm long) have as many as seven ligamental grooves, the upper ones not extending beyond the beak but the three lower ones forming asymmetric angles extending anterior to the umbo. The largest Recent specimen which we have seen is from Loc. 31389 (CAS). It was collected by W. D. Clark at Venado Island, Panama, and is 39 mm long, 25 mm high, the convexity (both valves together), 18.6 mm.

The present species has been recorded from beds of Pleistocene age in the Gulf of California region as well as in Panama and in Ecuador. The present record is the first of its occurrence in beds of Pliocene age.

The records of Melvill and Standen (107) of the doubtful occurrence of this species in the Persian Gulf are referable to some other species.

Barbatia (Fugleria) pseudoillota Reinhart (108) described from Pliocene strata near Santa Maria in Santa Barbara County, California, is a very similar species. The type specimen, a right valve, is 33.5 mm long, 31 mm high, and the convexity is 9 mm. It was described as less elongate than *B. (F.) illota* with about seven granular teeth anteriorly but completely lacking teeth on the hinge posteriorly. Our observations on the hinge of adult Recent specimens of *B. (F.) illota* agree with those of Reinhart, Woodring, and Rost, namely: that although there is a long edentulous area in the subumbonal area there are a few teeth at the posterior end.

Perhaps a large series of *Barbatia (Fugleria) pseudoillota* may reveal specimens with teeth on the

posterior end of the hinge but none of such have been reported.

Barbatia (Fugleria) tenera C. B. Adams (109), of which *B. balesi* Pilsbry and McLean (110) is a synonym, from the Floridan and Caribbean region is similar to *B. (F.) illota*. The fossils described as *Arca (Acar) millifolia* Dall (111) from "Pliocene of Shell Creek, Florida," and a varietal form *B. (A.) m. latrinidadis* Maury (112), from the "Pliocene" of "Matura", Trinidad, were compared by their authors with *B. (F.) illota*.

FAMILY GLYCYMERIDIDAE NEWTON (113)

Shell orbicular, subtrigonal or subquadrate, equilateral, valves closed; isomyarian, integripalliate; beaks usually orthogyrate, located nearly centrally or slightly to the posterior; ligament external, made up of chevron-shaped parts; hinge plate arched; teeth taxodont, absent or small and transverse at center, side teeth oblique or parallel to hinge, the larger ones chevron-shaped, internal ventral margin usually crenulated; exterior smooth or with radial ornamentation; shell material porcelaneous. (Adapted from Nicol, Jour. Paleo., Vol. 19, p. 616, 1945.) Cretaceous to Recent.

Remarks. — Bowden and Heppell (114) recently discussed the usage of the family names "Glycymeridae" and "Glycimeridae." The earliest valid usage of "Glycymeridae" for the present family is by Newton, 1916. Stenzel, Krause, and Twining (115), pointed out that the correct spelling for this name is Glycymerididae. The family name Glycymeridae attributed to Deshayes (116) ("Les Glycimerides.", vernacular) by Chenu and others is now synonymous with Hiatellidae Gray, 1824.

Nicol has contributed several papers dealing with this family. These include one dealing with the phylogeny (117) of the Glycymerididae, one summarizing the genera (118) and subgenera, and one dealing with distribution of living glycymerids. (119)

A paper by Baldi (120) deals with the species of *Glycymeris* s. str. of Oligocene and Miocene age in Europe.

GENUS GLYCYMERIS DA COSTA

Glycymeris Da Costa, Hist. Nat. Test. Brit., p. 168, 1778.

Species cited: "*G. orbicularis*," pl. 11, figs. 2, 2. In synonymy, "*Chama glycymeris* Bellon," reference to Lister, Hist. Conch., tab. 247, fig. 82. Also other references including Pennant, Brit. Zool., No. 58, tab. 58, fig. 58. "*Arca Glycymeris. Orbicularis*."

Not *Glycymeris* Lamarck, 1799 (= *Panope* Ménard, 1807).

Axinaca Poli, Test. Utrius. Sicil., Vol. 1, p. 32, 1791. Sole species: *Arca pilosa* [Linnaeus]. Type (designated by Gray, Proc. Zool. Soc. London for 1847, p. 198): "*Arca pilosa*." [Linnaeus.]

Axinaeoderma Poli, Test. Utrius. Sicil., Vol. 2, pp. 254, 260, 1795. "*Arca pilosa* Linn."

Pectunculus Lamarck, Mém. Soc. Hist. Nat. Paris, Vol. 1, p. 87, 1799. Sole species: "*Arca pectunculus* Lin." See remarks by Dall, Proc. Malacol. Soc. London, Vol. 10, Pt. 3, pp. 255-256, 1912.

Not *Pectunculus* Da Costa, 1778. (In superfamily Veneracea).

Type species (by tautonymy). — *Chama glycymeris* Bellon [= *Arca glycymeris* Linnaeus, Syst. Nat., ed. 10,

p. 695, 1758. "Habitat ad insulam Garnsey." Illustrated by Reeve, *Conch. Icon.*, Vol. 1, *Pectunculus*, pl. 3, figs. 12a-b, 1843. Coasts of Britain. For a discussion of this species, see Dodge, H., *Bull. Amer. Mus. Nat. Hist.*, Vol. 100, Art. 1, p. 157, 1952.]

Range. — Cretaceous to Recent. Recent, world-wide in warm and temperate marine waters (but not in Arctic and Antarctic), in 0-640 meters (0-350 fathoms), but usually in less than 110 meters (60 fathoms). One species reported from a depth of 1846 meters (1010 fathoms).

Description. — Shell suborbicular to subtrigonal in outline, slightly truncated posteriorly; cardinal area with chevron-shaped ligamental grooves; hinge curved, set with transverse teeth which are larger and more horizontal toward the outer margins; gradual subsidence of ligamental area during growth results in progressive obliteration of teeth along dorsal margin; posterior adductor impression with a slight flange.

Remarks. — The usage by various authors of the names *Glycymeris* and *Pectunculus* was discussed by Chavan (121). He also discussed (122) the muscular impressions of *Glycymeris*.

The genus *Glycymeris* apparently reached its greatest development in number and distribution of species during Miocene time. A number of species have been described from Tertiary strata of California but only two are known to occur in the San Diego Formation.

About 100 species of *Glycymeris* (*sensu lato*) live in tropical, subtropical and temperate waters, frequently on sand or on a sandy, muddy bottom. Fifteen species and subspecies have been described from west American waters.

SUBGENUS AXINOLA N. SUBGEN.

Type species. — *Axinaea* (?*septentrionalis*, var.) *subobsoleta* Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 627, 644, August, 1864. (Reprint in Smithsonian Misc. Coll., No. 252, pp. 113, 130, 1872). Cited from Oregon; region between San Diego and San Pedro, California; islands off the coast of California; Vancouver, British Columbia. — Carpenter, *Ann. Mag. Nat. Hist.*, Ser. 3, Vol. 14 (Nos. 5-37), p. 425, December, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 237, 1852. "Hab. Neeah Bay (Swan); Shoalwater Bay (Cooper)." For a discussion and illustration of this species see K. V. W. Palmer, *Geol. Soc. Amer.*, Mem. 76, p. 63, pl. 1, figs. 8-10, 1958. "Recent. Neeah Bay, Washington (type)."

Range. — Late Eocene to Recent. Recent from Lower California, Mexico, to Japan.

Description. — Shell small to moderate size (5 to 50 mm long), subtrigonal to suborbicular in outline, often produced posteriorly, convexity of valves slight, thin, sometimes chalky, the Recent species covered with a velvety periostracum; the exterior is smooth or with faint rather narrow, flat-topped radial ribs which become strongly accentuated by erosion; beaks usually opisthogyrate but in some species orthogyrate; cardinal area short, high, with ligamentary grooves forming asymmetrical triangles, the anterior side the longer; hinge arcuate, the central teeth much finer than those at either end or sometimes nearly obsolete; interior ventral margin of valves

crenulated, the crenulations with blunt ends.

Remarks. — At the time that the senior author and A. M. Strong studied the tropical west American species of *Glycymeris* it became evident to us that a group of species typified by *G. subobsoleta*, differed in shell characters from any described supraspecific unit. Later Dr. David Nicol came to the same conclusion during his study of the family Glycymerididae. The group of species, both Recent and fossil, here included in *Axinola*, appear to be confined to the borders of the northeastern Pacific region.

The combination of shell characters including the outline and the narrow, high cardinal area with decidedly asymmetrical ligamental grooves, and fine sculpture of the exterior differentiate *Axinola* from such groups as *Veletuceta* Iredale (123) and *Glycymerula* Finlay and Marwick (124).

The identification of the species in this group is fraught with difficulty. Willett (1944, p. 108) pointed out that this is caused by "the great amount of individual variation within the species. This applies not only to the shape, color and sculpture, but to the number of teeth, width of hinge-plate, width of ligamental area, and size and prominence of the umbos. Also there may be considerable morphological change between juvenility and maturity. There is often more similarity between the young of different species than there is between the adults; therefore, many young specimens are very difficult, if not impossible to identify."

Key to Species of *Axinola*

- A. Umbos high, prominent;
apical angle 83° to 88° *profunda*
- B. Umbos low, often flattened;
apical angle 93° to 106° *grewingki*

Glycymeris (*Axinola*) *grewingki* Dall Plate 27, Figures 14, 19, 22, 24

Glycymeris grewingki Dall, U. S. G. S., Prof. Paper 59, p. 107, pl. 2, fig. 13, April 2, 1909. — Stewart, in Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, p. 90, pl. 29, figs. 10, 11; pl. 33, figs. 7, 8, issued June 7, 1941. "Etchegoin formation of North Dome," Kettleman Hills. — Weaver, Univ. Washington Publ. Geol., Vol. 5, Pt. 1, p. 62, pl. 10, fig. 19, 1942 (issued December 31, 1943). (Holotype.)

Glycymeris coalingensis Arnold, U. S. G. S., Bull. 396, p. 80, pl. 19, fig. 3, 1909 (issued January 10, 1910). Loc. 4806 (U. S. G. S.), "Glycymeris bed on north side Alcalde Canyon, 2 miles northeast of Alcalde, center of SW. 1/4 sec. 7, T. 21 S., R. 15 E." [M.D.B.M.] Coalinga district, California." "Etchegoin formation, upper Miocene." [Pliocene.] — Arnold, in Eldridge and Arnold, U. S. G. S., Bull. 398, p. 131, pl. 41, fig. 3, 1910. (Holotype.) — Clark, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 8, No. 22, checklist opposite p. 400, pl. 48, figs. 9, 10, 1914. Upper and Lower San Pablo, late Miocene. — Slodkewitsch, Acad. Sci. USSR, Paleo. Inst., Paleo. USSR, Vol. 10, Pt. 3, Fasc. 18, p. 137; Fasc. 19, pp. 104, 212, pl. 9, fig. 4, 1938. (Copy of Arnold's pl. 41, fig. 3.) — Hall, Univ. Calif. Publ. Geol.

Sci., Vol. 34, No. 1, p. 50, pl. 1, figs. 1, 2, 3, 4, 1958. Oursan Formation, Pleasanton area, California, middle Miocene.

Type specimen. — No. 107784, United States National Museum.

Type Locality. — "Miocene of Coos Bay, Oregon." [Pliocene.]

Range. — Middle Miocene (Oursan Formation) to middle Pliocene.

Occurrence in San Diego Fm. — C.A.S. 1400. L.A.M. 305. S.D. 4, 150. U.C.L.A. 1386. S.D.S.C. 32, 223.

Original description. — Shell solid, suborbicular, subequilateral, equivalve; beaks prominent, moderately convex, slightly separated by the area, which is narrow, in each valve forming a wide, very obtuse triangle with deeply incised angular sulci, radiating from the vertical of the beak; anterior slope slightly shorter and more rounded than the posterior, which is somewhat produced toward the lower portion; there is no distinct lunule or escutcheon; but a feebly differentiated anterior dorsal area is characterized by radial threads much finer than those on the anterior half of the disk; on the latter are about a dozen flat, little-elevated, radial ribs, separated by much narrower, channeled sulci, the whole with more or less obsolete fine radial striation; these radial ribs are distinct when the surface of the shell is intact; the anterior half of the disk, except when decorticated, nearly smooth except for close-set uniform numerous radial threads which cover the entire surface; when decorticated the internal structure shows ribs much like those normally exposed on the anterior half of the disk. Altitude of figured specimen, 38 mm; longitude, 38 mm; diameter 20 mm. (Dall.)

Remarks. — A few specimens from the San Diego Formation are flatter and more rounded than those of typical *G. profunda*. The umbos do not curve over the cardinal area which bears finer ligamental grooves and the apical angle is about 100° . These resemble *G. growingki* Dall, especially those specimens illustrated by Stewart from late Pliocene strata on North Dome, Kettleman Hills, California. Some of the larger, more rounded specimens of *G. growingki* illustrated by Stewart (pl. 33, figs. 7, 8) have an apical angle of about 120° . *Glycymeris coalingensis* Arnold is a synonym. Stewart stated (1941, p. 90) ". . . the differences between *G. coalingensis* and *G. growingki* cited by Arnold being due to differences in the state of preservation of the type specimens." Large specimens from the coalinga area are 41 mm high.

Stewart suggested the possibility that some of the specimens from Kettleman Hills which he identified as *G. growingki* might be a flat variety of *G. profunda*. The relationship of *G. growingki* with the Recent forms described by Dall from southern California is not known.

The present specimens differ from *G. subobsoleta* Carpenter (125), a Recent species, in the higher umbos and correspondingly wider (dorsal-ventral) ligamental area and less prolongation posteriorly.

Willett pointed out that representatives of *Glycymeris subobsoleta* Carpenter in southern California often lack or nearly lack posterior elongation and the apical angle is about 90° . Presumably those southern shells would be referable to *G. corteziana* Dall (126) as interpreted by Woodring, Bramlette, and Kew, who gave the range of *G. subobsoleta* as Alaska to Oregon and that of *G. corteziana*

(considered to be a southern race of *G. subobsoleta*) as Forrester Island, Alaska, to Magdalena Bay, Lower California. They considered *G. migueliana* Dall (127) to be a synonym of *G. corteziana*.

The present flattish specimens bear considerable resemblance to *G. migueliana* Dall and its probable synonym *G. corteziana* Dall, the types of which were illustrated by Willett. The name *G. migueliana* has line priority over the name *G. corteziana* on the page containing the original description. Whatever the relationship may be the names *Glycymeris subobsoleta*, *G. profunda*, *G. growingki* and *G. coalingensis* all have priority over *G. migueliana* and *G. corteziana*.

Glycymeris vancouverensis Clark and Arnold (128), another member of this group described from the Sooke Formation on Vancouver Island, British Columbia, of late Oligocene or early Miocene age, was said to be closely related to *G. migueliana* but higher in proportion to the length and with a smaller apical angle.

Slodkewitsch (1938, pp. 104, 212, pl. 9, figs. 5, 5a) cited a species under the name of *Glycymeris coalingensis* from beds of Pliocene age in Kamtschatka but we have not seen specimens from that region.

Glycymeris (Axinola) profunda Dall

Plate 27, Figures 15, 20, 21, 23, 25, 28, 29, 30, 34, 37

Axinea profunda Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 13, July 1, 1878. — Schuchert et alii, U. S. Nat. Mus., Bull. 53, Pt. 1, p. 86, 1905. "Pliocene, San Diego, California." [Pleistocene.] — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 31, 1944. Earlier records cited.

Glycymeris septentrionalis [Middendorff], Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 82, 1929. "San Diego Pliocene."

Not *Pectunculus septentrionalis* Middendorff, 1849 [= *Glycymeris multicosata* Sowerby, 1833 (see Hertlein and Strong, Zoologica, Vol. 28, Pt. 3, No. 19, p. 151, 1943)].

Glycymeris profunda Dall, Willett, Bull. South. Calif. Acad. Sci., Vol. 42, Pt. 3, p. 111, pl. 11, figs. 3, 3a, September-December, 1943 (issued January 15, 1944). "taken in 200 fathoms off Santa Catalina Island," and "in 25 fathoms off Redondo, Los Angeles County." "Common in some Lower Pleistocene deposits, particularly so at Hill Top Quarry, San Pedro."

Glycymeris profunda Dall, Woodring, Bramlette, and Kew, U. S. G. S., Prof. Paper 207, p. 79, pl. 30, figs. 5-8, 1946. "Lomita Marl" at "Hilltop Quarry," also in "San Pedro sand," early Pleistocene.

Type specimen. — Lectotype from type lot No. 7935, United States National Museum.

Type locality. — Indicated as from "San Diego" (p. 11). On p. 29, cited from "recent alluvial soil, eight or ten feet above tide-water, is another stratum (D), in which the specimens are in a poor state of preservation." [According to Woodring, Bramlette, and Kew (1946, p. 79), "The type material was collected evidently from the Pleistocene strata overlying the Pliocene San Diego formation at Pacific Beach."]

Range. — Middle Pliocene to Recent. Recent from off Redondo and off Catalina Island, California, in 46 to 366 meters (25 to 200 fathoms).

Occurrence in San Diego Fm. — C.A.S. 28886. L.A.M. 124, 302, 305, 305A. S.D.S.C. 223.

Original description. — Shell subtriangular, ventral margin rounded, umbos erect, rather small. Area narrow, deep; marked by five or six lines meeting at an angle in the verticle of the umbo, one above another; anterior lines somewhat the shortest; exterior marked by twenty-five or thirty flattened ribs, separated by deep channels one-fourth as wide as the ribs, and by which the interior margin is crenulated. The ribs are crossed by thread-like close lines of growth, which may be elevated or obsolete on the ribs, but are sharply defined in the channels, which they partially fill up in some specimens. Toward the anterior and posterior margins, the sculpture is nearly obsolete. In eroded examples, this sculpture may be entirely altered, and such are hardly recognizable as the same thing. Interior smooth or lightly radiately striate, with a tendency to an elevated narrow ridge behind the anterior scar; hinge with teeth placed as if radiating from the centre of the valve, six to nine anteriorly, and ten to fourteen posteriorly, with some ten or twelve small, crowded teeth between the two radiating sets, and placed perpendicularly and parallel with one another. Height, 32 mm; length, 30 mm; thickness, 20 mm; the last proportionally greater in the young. (Dall.)

Remarks. — *Glycymeris profunda* is represented in collections from the San Diego formation from several localities, the largest number from Loc. 305 (LAM) near the Mexican boundary. There are over two hundred specimens from that locality varying in size from about 4 to 28 mm in height.

These specimens are high, thick, rounded trigonal, convex valves with high prominent umbos, the beaks curving over the rather wide (dorsal-ventral) cardinal area. The ligamental grooves are asymmetrical and on the more globose specimens rather coarse. The exterior of the shell is smooth when the preservation is perfect. Usually, however, removal of the outer layer by erosion exposes radial ribbing. Some of the globose valves agree almost exactly with specimens from the Pleistocene at Pacific Beach, part of the original lot of *Glycymeris profunda* which bear numbers 696 and 696a (see plate 27, figs. 15, 23, 28, 29) in the type collection of the Department of Paleontology of the California Academy of Sciences. One of the larger specimens in that lot is 23 mm long, 23.4 mm high, convexity (one valve), 9.3 mm, apical angle about 100°. The arcuate hinge bears about 22 teeth. Many of the specimens in the present collections agree with the illustrations of *G. profunda* from beds of Pleistocene age in the San Pedro region, published by Woodring, Bramlette, and Kew.

Arnold (129) illustrated two specimens from the Pleistocene of San Pedro, one cited as *G. barbarensis* Conrad (fig. 9) and one as *G. septentrionalis* Middendorff (fig. 10). Willett considered both of these to be referable to *G. profunda*. Woodring, Bramlette, and Kew stated that Arnold's figure nine was similar to but of less height than typical *G. profunda*. Most of the specimens in the present collections from San Diego bear a similarity to Arnold's figure nine, but some, especially the flatter, higher ones, are similar to his figure 10. Judging from the variation in the globosity, height, and character of the ligamental grooves revealed in the series of specimens at hand, support is given to Willett's suggestion that both of

Arnold's figures may be referable to *G. profunda*.

The identification of *Glycymeris barbarensis* Conrad (130) described over a century ago is involved in nomenclatorial problems because two different species were described under that name. No locality was cited by Conrad for the species illustrated in volume 6 of the Pacific Railroad Reports except that the title refers to "Tertiary Fossils" and in the text "California fossils", which Conrad believed "appear to represent the Miocene period" (131). The specific name would imply that it was believed to have been found in the Santa Barbara region. Woodring, Bramlette, and Kew ventured the opinion that the fossil, presumably of Pleistocene age, illustrated by Conrad is a possible synonym of the Recent *G. subobsoleta* Carpenter. Whatever the identification of *G. barbarensis*, it definitely appears to be distinct from typical *G. profunda*. According to Woodring, Bramlette, and Kew, the species cited under the name of *Axinaea barbarensis* in volume 7 of the Pacific Railroad Reports is probably referable to *Glycymeris veatchii* Gabb.

Glycymeris subobsoleta Carpenter (see K. V. W. Palmer, 1958, p. 63, pl. 1, figs. 8-10) has a thin shell which is elongated posteriorly and has a narrow cardinal area. The shell characters of some young specimens of *G. profunda* approach those of *G. subobsoleta* and *G. grawingi*.

Glycymeris tenuimbricata Clark (132), a species with high slender umbos, from the San Ramon beds of late Oligocene or early Miocene age, has an apical angle of about 90° and bears a general resemblance to some specimens of *G. profunda*, but it has a much narrower cardinal area.

Glycymeris keenae Willett (133) from Alaska was described as a small (13.5 mm long) white shell with concentric sculpture and an angular hinge plate. Its general features are similar to those of *G. profunda* and allied species.

In addition to the occurrences at San Diego and San Pedro, California, *G. profunda* has been reported (the identifications mostly doubtful) from beds of Pleistocene age from Cayucos, California, to northern Lower California.

ORDER DYSODONTIDA NEUMAYR (FISCHER)
SUPERFAMILY MYTILACEA RAFINESQUE (134)
FAMILY MYTILIDAE RAFINESQUE (135)

Shell elongately ovate, bullet to wedge-shaped, often with an oblique axis, the valves equal. Beaks small, prosogyrate, placed usually near the anterior end, the umbonal slope posteriorly, often prominent and vaulted. Hinge line posterior of the beaks usually straight, plain or with a crenulated margin in harmony with a ribbed external sculpture, edentulous, or with small dysodont teeth on the anterior lunular margin below the beaks. Ligament subinternal, attached to an elongated calcified resilifer, usually white in color, compact or with pitted or cellular basal foundation. Typically dimyarian, the anterior adductor scar is always much smaller than the other and sometimes wholly eliminated in the adult, hence the posterior adductor scar is large and sometimes confluent with that of the posterior retractor. Surface smooth or with radial riblets; the sculpture is usually much stronger on the posterior-dorsal side, finer on the ventral side of the umbonal slope. Inner layer of the shell

is ordinarily nacreous, the outer layer thinner, darker, and covered by a thin or heavy, yellow, brown, green or black periostracum, hairy or bristly, often peeling off from dead valves. Marine, brackish to freshwater. (Olsson, *Mollusks of the Tropical Eastern Pacific* (Paleo. Res. Inst.: Ithaca, New York, pp. 110-111, 1961.) Devonian to Recent.

Remarks. — The members of this family are often attached by a byssus or, as mentioned by Tryon, they frequently conceal themselves by spinning a byssal nest of sand and shell fragments, or they live in the burrows of other mollusks, or they burrow into soft substances.

Newell (136) discussed members of this family occurring in the late Paleozoic and Cox (137) remarked on the derivation of some of the genera in the Mesozoic Era.

A monograph by Soot-Ryen (138) dealing with the Recent west American species of this family appeared in 1955. He recognized 56 species which he distributed in 23 genera and 6 subgenera.

This family is represented in the San Diego formation by seven genera.

Key to Genera of Mytilidae

- A. Sculpture divided into three distinct areas *Gregariella*
- B. Sculpture not divided into three areas; or smooth
 - a. Beaks terminal or nearly so; teeth on anterior portion of hinge
 - b. Interior with a small, triangular septum under the beaks *Septifer*
 - bb. Interior lacking septum under the beaks
 - c. Shell usually not exceeding 3.5 mm in length; ovate with fine, even, radial sculpture *Crenella*
 - cc. Shell exceeding 3.5 mm in length; often elongated or cuneiform
 - d. Margin strongly crenellated posterior to the ligament; radial sculpture coarse on dorsal, fine on ventral area. *Acidimytilus*
 - dd. Margin posterior to the ligament smooth; exterior smooth or occasionally with radial sculpture *Mytilus*
 - aa. Beaks not terminal; teeth lacking on anterior portion of hinge
 - c. Shell obliquely oblong *Modiolus*
 - cc. Shell subcylindrical *Lithophaga*

GENUS MYTILUS LINNAEUS

Mytilus Linnaeus, Syst. Nat., ed. 10, p. 704, 1758. Seventeen species cited including *Mytilus edulis*. — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 95, 1930. Anton's designation of *Mytilus edulis* as type accepted. — Cox, Mem. Geol. Surv. India, Palaeo. Indica, Ser. 9, Vol. 3, Pt. 3, p. 74, 1940. "Genotype. — *Mytilus edulis* Linné (1758, p. 705), Recent, European Seas."

Type species (designated by Anton, Verzeich. Conchyl., p. 17, 1839). — *Mytilus edulis* Linnaeus. *Mytilus* with *M. edulis* designated as type by Anton was placed on the Official List of Genera by the Internatl. Comm. Zool. Nomencl., Opinion 94, in 1926. [*Mytilus edulis* Linnaeus, Syst. Nat., ed. 10, p. 705, 1758. "Habitat in O. Europaeo, Indico & M. Balthico". Ref. to Lister, Conch., 3, t. 362, fig. 20; Gualtieri, Test., t. 91, fig. E; also others. — Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 4, p. 136, pl. 26, figs. 1-4, 1890. Mediterranean region, Black Sea, and England.]

Range. — Jurassic to Recent. Recent, world wide, from the intertidal zone to about 91 meters (50 fathoms).

Description. — Shell elongated and with terminal or subterminal pointed beaks; a thin nacreous layer present; valves with ventral margin nearly straight but wider and rounded posteriorly, gaping slightly for a byssus; smooth or radially sculptured; periostracum conspicuous; a few small teeth on a very small plate beneath the beaks or edentulous (lacking in some Mesozoic forms); anterior adductor impression small or lacking, high in umbonal cavity; posterior adductor impression larger, bilobed; pallial line not parallel to margin of valves.

Remarks. — Most species of the Mytilidae in the Cenozoic are readily referable to *Mytilus* or *Modiolus*. Among the Mesozoic forms, as pointed out by Cox (1940, p. 75), the differences in shell characters between the two are less distinct and there are fossil as well as Recent forms whose shell characters are intermediate between the two genera. The same author mentioned that from present knowledge of fossil forms of this group it appears that *Mytilus* descended from *Modiolus*.

Three species of *Mytilus* have been recorded as occurring in strata of Pliocene age in California, two of which have been reported from the San Diego formation.

Key to Subgenera of *Mytilus*

- A. Anterior adductor impression small and shallow: anterior ventral margin smooth *Mytilus* s. s.
- B. Anterior adductor impression large and deep; anterior ventral margin minutely crenulated *Crcnomytilus*

[SUBGENUS MYTILUS S. S.]

[*Mytilus edulis* Linnaeus]

Mytilus edulis Linnaeus, Syst. Nat., ed. 10, p. 705, 1758. [*Mytilus edulis* was placed on the Official List of specific names in Zoology by the Internatl. Comm. Zool. Nomencl. in Opinion 333, signed July 8, 1954, published February 23, 1955.] — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 66, pl. 27, fig. 4, 1924. "In the Pliocene, Benicia,

Solano County, and San Diego, California." — Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 213, 1952. Cosmopolitan. — Soot-Ryen, Alan Hancock Pac. Exped., Vol. 20, No. 1, p. 19, pl. 1, figs. 1, 2, text figs. 1, 2, 10, 11, 1955. Cosmopolitan.

Type locality. — "Habitat in O Europaeo, Indico & M. Balthico."

Remarks. — The only record of the occurrence of *Mytilus edulis* in the Pliocene at San Diego is that of I. S. Oldroyd. We have not observed any specimens in the collections from the San Diego Formation which are referable to this species and we are therefore unable to validate the record of Oldroyd.

This species has been recorded from several other localities in California in strata of Pliocene age including the Falor Formation, Merced Formation, San Joaquin Formation (cf.), and in the Fourth Street Tunnel in Los Angeles. It also has been recorded as occurring from middle Miocene (139) to Recent in this region.

Mytilus edulis, or subspecies of it, occur in most of the seas of the world except in extreme tropical waters. Field (140) gave an extensive discussion of its biology and economic value and Seed (141) recently discussed the variation in the shape of the shell of this species.

SUBGENUS *CRENOMYTILUS* SOOT-RYEN

Crenomytilus Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 23 November 10, 1955. "Type of genus: *Mytilus grayanus* Dunker, 1853."

Mytiloconcha of west American authors, not *Mytiloconcha* Conrad, 1862.

Type species (by original designation). — *Mytilus grayanus* Dunker [Zeitschr. f. Malakozool., Jahrg. 10, No. 6, p. 84, July, 1853. "Habitat ad insulam Javam." Illustrated by Soot-Ryen, 1955, p. 24, pl. 2, figs. 9, 10, text fig. 7. Japan. — Habe and Ito, Shells of the world in colour, Vol. 1, The northern Pacific (Hokkusha: Osaka, Japan), p. 112, pl. 36, fig. 5, 1965].

Range. — Late Oligocene or early Miocene to Recent.

Original description. — Shell mytiliform with terminal umbones, lunule grooved and incurved, forming two to three large teeth usually obsolete in old specimens, as there is a pronounced tendency to a growth in thickness by depositing new shell material on the inside of the valves. Margins, especially the anteroventral one, finely crenulated, the crenulations apparently formed as a result of the building up of the crystals in the valves; shell obliquely striated, especially distinct on the ventral surface. Resilial ridge compact; anterior adductor strong, showing a distinct thickened scar; anterior retractor scar elongate behind umbo; posterior adductor and retractor scars continuous. The soft parts have not been studied. (Soot-Ryen, 1955.)

This group of mytiliform species is distinguished from similar forms by the compact resilial ridge, the strong anterior adductor and the fine crenulation of the margins. (Soot-Ryen.)

Remarks. — West American Tertiary species referred to *Crenomytilus* by Soot-Ryen are: *Mytilus mathewsonii* Gabb, *M. trampasensis* Clark, *M. kawi* Nomland, and *M. coalingensis* Arnold. The new subspecies, *M. coalingensis sternbergi*, obviously belongs with this group of species. *Mytilus schencki* Hanna and Hertlein, described from

strata of late Miocene age, is probably referable to the subgenus *Crenomytilus* but we have not seen specimens in which uneroded margins could be observed. The only Recent species referred to this subgenus by Soot-Ryen was the type species, *M. grayanus* Dunker (*M. dunkeri* Reeve), from Japan and neighboring regions.

Mytilus (Crenomytilus) coalingensis sternbergi

n. subsp.

Plate 41, Figures 10, 14

Mytilus coalingensis Arnold, Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 85, 1929. "San Diego fauna". "Pliocene." — Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. "San Diego formation." Also Niguel Formation and Careaga Sandstone and upper part of Foxen Mudstone.

Not *Mytilus (Mytiloconcha) coalingensis* Arnold, U. S. G. S., Bull. 396, p. 73, pl. 19, fig. 5; pl. 22, fig. 6, 1909 [issued January 10, 1910]. Type locality 4656, (see p. 33), "at northwest end of Anticline Ridge, 6 miles north-northeast of Coalinga, SW. 1/4 sec. 34, T. 19 S., R. 15 E." [Mount Diablo Base and Meridian]. "Lowest Etchegoin bed or *Glycymeris* zone, just below bed of 4657." "Etchegoin (upper Miocene)." [Pliocene.]

Mytilus sp. (large), Hertlein and Allison, Bull. South. Calif. Acad. Sci., Vol. 58, Pt. 1, January-April, p. 21, issued May 11, 1959. Three localities between kilometer marker 258, Ensenada-San Quintin highway, to terrace east of San Simon and Agua Chiquita, northwestern Lower California, late Pliocene.

Type specimen. — Holotype, Los Angeles County Museum, from Loc. 107 (LAM), 100-foot bluff with fossiliferous concretions in clay quarry at end of Arroyo Drive, San Diego; San Diego Formation, middle Pliocene.

Additional Occurrences in San Diego Fm. — C.A.S. 1402. L.A.M. 302. S.D. 3209.

Description. — Shell large, resembling *Mytilus coalingensis* in general shape and trace of the lines of growth. It differs from that species in that the valves are less convex. Dimensions: length, 238 mm, width, 134 mm, convexity near the umbonal area, 59 mm.

Remarks. — The presence of a large anterior adductor impression on some of the present specimens is similar to that on the type species of *Crenomytilus*. Minute crenulations on the anterior ventral margin, characteristic of *Crenomytilus* are not visible on our specimens. Fine transverse rows of pustules on the exterior of the anterior ventral end of *M. coalingensis* from Pliocene strata in the San Joaquin Valley suggest that the inner margin of the valves of that species is crenulated.

One specimen, referred to the new subspecies in the collections of the California Academy of Sciences and one in the Los Angeles County Museum, consist of the beak and a portion of the umbonal area. A specimen in the latter institution from Loc. 302 (LAM) is 48.5 mm long and 33.6 mm in maximum width. A large anterior muscle impression similar to that of *M. coalingensis* is observable on these specimens.

One internal cast ("Steinkern") from Kensington Park in San Diego in the collections of the San Diego Society of Natural History is 130 mm long and 73 mm wide.

Woodring (142) mentioned the occurrence of casts

of a *Mytilus* in the Careaga beds and Foxen mudstone of Pliocene age in the Santa Maria district, which he compared with *M. coalingensis* but which he stated were flatter than the valves of that species. His description of these casts is reminiscent of the specimen from Loc. 3209 (SD).

The shell of *Mytilus coalingensis sternbergi* is broader posteriorly and it is more curved toward the beaks than is that of *M. mathewsonii* Gabb (143). The anterior ventral margin of the new subspecies is more curved than that of *M. mathewsonii expansus* Arnold (144) and *Mytilus kewi* Nomland (145). *Mytilus schencki* Hanna and Hertlein (146) is very much more broadly expanded posteriorly.

The new subspecies, at the present time, is known only from strata of middle Pliocene age in southern California and northwestern Lower California. *Mytilus coalingensis* is often encountered in beds of late Pliocene age in San Joaquin Valley. It has been recorded from as far north as the Sargent Oil Field (147) in Santa Clara Co., and specimens referred doubtfully to Arnold's species have been reported (148) from the lower Merced Formation in San Mateo Co., California.

Specimens cited as "*Mytilus coalingensis* Arnold, n. var.?" were reported by B. L. Clark (149) from beds presumably of late Miocene age in Contra Costa Co., California.

GENUS AEIDIMYTILUS Olsson

Aeidimytillus Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 120, March 10, 1961.

Type species (by original designation). — "Type species *Mytilus adamsianus* Dunker."

Range. — Middle Pliocene (and perhaps earlier) to Recent. Recent in Temperate and tropical waters, chiefly intertidal, reported to a depth of 55 to 91 meters (30 to 50 fathoms).

Original description. — Shell small, mytiliform with ribbed sculpture, usually divided, the ribs on the posterior-dorsal side of the umbonal ridge much coarser. Ventral side usually strongly impressed resulting in a high, angular umbonal ridge and often a distorted appearance to the whole shell. Adductor and pallial impressions united, but smaller and narrower than in *Scolimytillus*. (Olsson.)

Remarks. — Some of the west American Mytilidae with small shells, especially those described as *Mytilus multiformis* Carpenter and *Mytilus adamsianus* Dunker, have been variously placed in the generic or subgeneric categories of *Brachidontes* Swainson (150) and *Hormomya* Morch (151). Recently Olsson, believing that these small species combine some of the characters of both of the foregoing categories, proposed a genus *Scolimytillus* (152) and subgenus *Aeidimytillus* to include this group of species. We assign generic status to *Aeidimytillus* with the type species *Mytilus adamsianus* Dunker, at least until there is more general agreement concerning the systematics of these small mytilids.

The shells of this group usually develop a strongly arched umbonal ridge, coarse sculpture on the dorsal area and fine sculpture on the ventral area.

Aeidimytillus adamsianus Dunker

Plate 42, Figures 4, 5

Mytilus adamsianus Dunker, Proc. Zool. Soc. London for 1856, p. 360, issued May 8, 1857. — Reeve, Conch. Icon., Vol. 10, *Mytilus*, sp. 55, pl. 11, fig. 55, 1858. Panama. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 66, pl. 29, fig. 4, 1924. Santa Barbara, California, to Panama and the Galápagos Islands.

Mytilus stearnsi Pilsbry and Raymond, Nautilus, Vol. 12, No. 6, p. 70, "plate 4, figs. 1, 2, 3," October, 1898. "San Diego," California. [So far as we know the plate here referred to was not published.] — Gardner, Jour. Entom. Zool., Vol. 9, No. 3, p. 107, pl. 1, fig. 3, 1917. Laguna Beach, California. — M. Smith, Panamic Marine Shells (Trop. Photogr. Labor.: Winter Park, Florida), p. 53, fig. 694, 1944. San Diego, California, to Chile.

Mytilus (Hormomya) adamsianus Dunker, J. Q. Burch, Min. Conch. Club South. Calif., No. 36, p. 10, June, 1944. Cape San Lucas, Lower California, to Panama.

Mytilus (Hormomya) stearnsi Pilsbry and Raymond, T. Burch, Min. Conch. Club South. Calif., No. 36, p. 16a, fig., June, 1944. Punta Banda, Lower California, Mexico.

Brachidontes (Hormomya) adamsianus Dunker, Hertlein and Strong, Zoologica, Vol. 31, Pt. 2, p. 70, 1946. Santa Barbara, California to Panama, and the Galápagos Islands.

Hormomya adamsiana Dunker, Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 37, pl. 3, fig. 11; text-figs. 22, 25, 31, 1955. Santa Barbara, California, to Ecuador. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, Calif.), p. 48, fig. 83, 1958. California to the Gulf of California and south to the Galápagos Islands.

Scolimytillus (Aeidimytillus) adamsianus Dunker, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 121, pl. 12, fig. 5; pl. 13, figs. 4, 4a, 6, 1961. Lower California to Puerto Callo (Jipijapa), Ecuador.

Type specimen. — Type lot in British Museum (Natural History) (according to A. M. Keen, written communication, April 22, 1965).

Type Locality. — "Hab. Ad Isthmum Panamense (Cuming)."

Range. — Middle Pliocene to Recent. Recent from Santa Barbara, California, to Puerto Callo (Jipijapa), Ecuador, and the Galápagos Islands. Intertidal, usually under rocks and stones. Reported to a depth of 55 to 91 meters (30 to 50 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305C.

Original description. — M. testa ovato-trigona, utrinque obtuse carinata, solidula, costis mature bifidis eleganter granosis sculpta, fusco-purpurascens et albida; epidermide cornea vestita; umbonibus terminalibus; margine crenato.

Testa parva 10 lin. longa, 5 1/2 lin. alta, 4 1/2 lin. lata. (Dunker.)

Remarks. — Three valves of this species, somewhat eroded, are present in the collection from Loc. 305c (LAM), from near the Mexican boundary. The largest one is 18.9 mm long and 7.2 mm high (incomplete).

Other workers have remarked upon the variability in size and shape of a series of specimens of this species. This is probably, in part, a result of the habitat under stones and in crevices in rocks.

The beaks are small and nearly terminal and the umbonal ridge is high. The ribbing and general shell characters of the present valves agree exactly with specimens from west Mexico and Central America. The ribs on typical specimens of *Aeidimytilus adamsianus* are coarse on the dorsal area, they increase posteriorly by divarication or by addition. They are granulated as a result of successive step-like resting stages. The ribs on the ventral area are much finer. The dorsal area is brownish purple, the ventral area yellowish white. Interiorly the dorsal margin above the ligamental groove is strongly crenulated. The external appearance of this shell is remarkably similar to that of *Septifer bifurcatus*. Some specimens are sculptured with fine ribs but such forms agree in all other shell characters with the coarsely ribbed ones.

It appears that this species reaches a greater size in the northern part of its range. The largest specimens in the collections of the California Academy of Sciences, from three widely separated localities respectively are: from San Diego, 22.5 mm long and 12.3 mm high; from San Luis Gonzaga Bay, east coast of Lower California, 20.5 mm long; from Piedra Blanca, Costa Rica, 15 mm long. We are uncertain of the identification of the species from Costa Rica cited by Miller (1953) under the name of *Mytilus adamsianus* which was 53 mm long and 34 mm wide.

We have not found any constant differences, other than size, in shells from southern California and those from Central America and the Galápagos Islands. This leads us to include *Mytilus stearnsi* Pilsbry and Raymond in the synonymy of *A. adamsianus* Olsson (1961) published excellent illustrations of this species.

Some authors have believed that the nomenclature of this species is involved with that of *Mytilus multiformis* Carpenter. An illustration of a drawing of *M. multiformis* by Carpenter, in the United States National Museum was published by Olsson (1961, pl. 17, fig. 11). According to Olsson, Carpenter's manuscript sketches indicate "a small, short, fan-shaped shell with a large, smooth, nepionic area followed by two or more sculptured areas set off sharply from each other and the nepionic disk by resting lines; . . ." The shell characters of the species mentioned by Olsson are distinct from those of typical *A. adamsianus*. Another illustration of Carpenter's species was published recently by Brann (1954.)

GENUS *SEPTIFER* RÉCLUZ

Septifer Récluz, Rev. Zool., Soc. Cuvierienne, Vol. 11, p. 275, 1848. — Davies, Tertiary Faunas (Thomas Murby and Co.: London), Vol. 1, p. 191, 1935. — Lamy, Jour. de Conchyl., Vol. 80, No. 3, p. 239, 1936. — Iredale, Brit. Mus. (Nat. Hist.), Great Barrier Reef. Exped., 1928-29, Sci. Repts., Vol. 5, No. 6, Moll., Pt. 1, p. 424, 1939. Type as designated by Stoliczka.

Type species (designated by Stoliczka, Mem. Geol. Surv. India, Palaeont. Indica, Ser. 6, Cret. Fauna South India, Vol. 3, pp. xxi, 366, 1871). — "type, *S. bilocularis*,

Linn." [= *Mytilus bilocularis* Linnaeus, Syst. Nat., ed. 10, p. 705, 1758. "Habitat in O. Indico." For synonymy and a discussion see *Brachidontes (Septifer) bilocularis* Linnaeus, Prashad, Siboga Exped., Monogr. 53, p. 69, p. 2, figs. 21-24, 1932. East Indies. Widespread in the Indopacific.]

Range. — Triassic (155) to Recent. Recent from the intertidal zone to about 55 meters (30 fathoms).

Description. — Shell generally short, modioliform, with a high umbonal angle, the external surface sculptured with small radial riblets, often with bristles. Hinge and posterior margins strongly crenulated, the short anterior side with small dysodont teeth as in *Brachidontes* and with a small deck or platform placed like a shelf in the umbonal cavity below the beaks. (Olsson, A. A., Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 122, 1961.)

Remarks. — The presence of an umbonal deck interiorly readily serves to separate the shells of *Scptifer* from other members of the Mytilidae.

Five species of this genus have been reported from strata of Tertiary age in California. One species is reported here for the first time from the San Diego formation. Two, possibly three species, live in eastern Pacific waters.

Lamy (1936) discussed Recent species of this genus represented in the collections of the Museum of Natural History in Paris.

Septifer bifurcatus Conrad Plate 42, Figures 6, 12

M[ytilus]. bifurcatus Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 241, pl. 18, fig. 14, 1837. — Reeve, Conch. Icon., Vol. 10, *Mytilus*, sp. 41, pl. 9, fig. 41, 1857.

Septifer bifurcatus Conrad, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 119, 1903. Pleistocene and Recent. — Gardner, Jour. Entomol. Zool., Vol. 9, No. 3, p. 107, pl. 1, fig. 4, 1917. Laguna Beach, California, Recent. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 247, 1931. Pleistocene and Recent. — Johnson and Snook, Seashore Animals of the Pacific Coast (Macmillan Co.: New York), ed. 1935, p. 429, fig. 389 (p. 430), 1935. "Northern California to the Gulf of California." — Nomura, Venus, Vol. 6, No. 4 p. 206 (in text), figs. 6a-d, 1936. California. — Ricketts and Calvin, Between Pacific Tides (Stanford Univ. Press: Stanford, Calif.), p. 99, pl. 22, fig. 3, 1939. Recent. — Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 41, pl. 4, figs. 19, 20; text fig. 33, 1955. Crescent City, California, to Cabo San Lucas, Baja California, Recent.

Type specimen. — No. 57920, Academy of Natural Sciences of Philadelphia (see A. M. Keen, Veliger, Vol. 8, No. 3, p. 169, 1966).

Type locality. — "Inhabits, attached to rocks bare at low water, in the Sandwich Islands, (Ouaou, &)." [Locality erroneous. This species is now believed to be a member of the molluscan fauna of California. See note by Henderson (Nautilus, Vol. 40, No. 3, p. 81, 1927) dealing with Californian species erroneously described from Hawaii by Conrad; also Keen, A. M., Min. Conch. Club South. Calif., No. 36, p. 11, June, 1944.]

Range. — Middle Pliocene to Recent. Recent from Crescent City, California, to Asuncion Island, and perhaps to Cape San Lucas, Lower California, Mexico. Often attached by byssus to underside of rocks; to 22 meters (12 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305C. S.D.S.C. 47.

Original description. — Shell narrowed, slightly arcuate; anterior margin much flattened; ribs narrow, prominent, bifurcated towards the base; colour dark purple. Height, one and a half inches. (Conrad.)

Remarks. — *Septifer bifurcatus* is here reported for the first time from strata of Pliocene age. One valve, somewhat eroded, 18.2 mm long and 10.8 mm wide, is present in the collection from Loc. 47 (San Diego State Coll. Dept. Geol. Coll.) from Tijuana River Valley. One valve, 10 mm long from near the Mexican boundary, is present in the collections of the Los Angeles County Museum. The largest Recent specimen in the collections of the California Academy of Sciences collected by Henry Hemphill at Loc. 5889 (CAS), San Diego, California, is 41.5 mm long and 18 mm high. Some large valves become partially or almost entirely smooth after attaining a length of about 25 mm. Shells similar to these with obsolete radial sculpture were described as *Septifer bifurcatus* var. *obsoletus* Dall. (1956)

The species living in tropical and subtropical west American waters formerly referred to *Septifer cumingii* Récluz is now known as *S. zeteki* Hertlein and Strong (1957).

Records by Melvill and Standen (158) of *S. bifurcatus* from the vicinity of the Falkland Islands are undoubtedly referable to some other species.

A species in Japan, formerly cited under the name of *Septifer bifurcatus* Conrad, later described as *S. keeni* by Nomura (159), is now referred to *S. grayanus* Dunker (160) by Habe (161).

Septifer margaritana Nomland (162), a species of late Miocene age from about ten miles northeast of Coalinga, California, was described as larger (52 mm long, 22 mm high) than *S. bifurcatus*, with more numerous radiating riblets and with a more acute umbonal angulation. We have examined a cast of the holotype which reveals the shell characters mentioned by Nomland.

GENUS MODIOLUS LAMARCK

VolSELLA Scopoli, *Introd. Hist. Nat.*, p. 397, 1777. Species cited, "*Mytilus Modiolus* Linn. *dente unico*"; "*Gula Soricis* Lister. *dentibus* 1-2."; "*Mytilus*. L. Aber. Adans. *dentibus pluribus*." [According to E. Fischer-Piette et al. (*Jour. de Conchyl.*, Vol. 85, No. 4, p. 298, pl. 13, fig. 2, 1942) *Gula soricis* Lister is referable to *Brachidontes puniceus* Gmelin.] — Gray, *Proc. Zool. Soc. London* for 1847, p. 198, 1847. Type, *Mytilus modiulus* Linnaeus. — Grant and Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, p. 248, 1931. Type as indicated by Gray.

Modiolus Lamarck, *Mem. Soc. Hist. Nat. Paris*, p. 87, 1799. Sole species, "*Mytilus modiulus*." — Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20 No. 1, p. 56, 1955. Type (according to Gray, 1847): *Mytilus modiulus* Linnaeus. [*Modiolus* ruled a *nomen conservandum* and placed on the official list of generic names in Zoology

with the type species, *Mytilus modiulus* Linnaeus, by Internatl. Comm. Zool. Nomencl., Opinion 325, signed May 8, 1954, published January 7, 1955.]

Modiola Lamarck, *Syst. Anim. S. Vert.*, p. 113, 1801. Sole species "*Modiola papuana*, n. Argenv. t. 22, fig. C. *Encycl.* t. 219, fig. 1. *Chemn.* 8, t. 85, f. 757. *Vulg.* la moule des Papous." — Bucquoy, Dautzenberg, and Dollfus, *Moll. Mar. Roussillon*, Vol. 2, Fasc. 4, p. 150, April, 1890. — Jukes-Brown, *Proc. Malacol. Soc. London*, Vol. 6, No. 4, p. 221, March, 1905.

Eumodiola von Ihering, *Proc. Malacol. Soc. London*, Vol. 4, p. 87, August, 1900. "Type, *M. modiulus*, Linn."

Type species (by monotypy and by absolute tautonymy, and by ruling of the Internatl. Comm. Zool. Nomencl., Opinion 325) — *Mytilus modiulus* Linnaeus [*Syst. Nat.*, ed. 10, p. 706, 1758. "*Habitat in M. Mediterraneo*." Ref. to Rumphius, *Mus.*, t. 46, fig. B; Argenville, *Conch.*, t. 25, fig. C.; Bradl. *Nat.*, t. 3, fig. 1. Illustrated by Reeve, *Conch. Icon.*, Vol. 10, *Modiola*, pl. 1, fig. 2, 1858. "North Atlantic shores of Europe and America." — Clessin in Martini and Chemnitz, *Conchyl. Cab.*, Bd. 8, Abt. 3, *Mytilidae*, p. 92, pl. 5, fig. 3, 1889. — Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 66, text figs. 47, 48, 52, 1955].

Range. — Devonian to Recent, world wide, marine. Recent from the intertidal zone to a depth of at least 183 meters (100 fathoms).

Description. Shell obliquely oblong, expanded posteriorly and inflated along an oblique medial line from the umbonal end to the posterior ventral margin; dorsal margin curved or angulated; anterior end usually produced beyond the umbones; exterior with a hairy periostracum; hinge edentulous or often with a tooth-like projection on anterior margin just below the anterior end of the ligament.

Remarks. — A number of species of *Modiolus* have been described from strata of Tertiary age in western North America of which five have been recorded as occurring in beds of Pliocene age. Eight Recent species living in west American waters were assigned to this genus by Soot-Ryen. These range from the intertidal zone to a depth of 183 meters (100 fathoms) but most of them occur most abundantly in waters less than 92 meters (50 fathoms) in depth. Many of the species build "nests" of sand and byssus threads.

Modiolus rectus Conrad Plate 42, Figure 7

M [odiola]. recta Conrad, *Jour. Acad. Nat. Sci. Philadelphia*, Vol. 7, Pl. 2, p. 243, pl. 19, fig. 1, 1837. — Dall, *Proc. Calif. Acad. Sci.*, Vol. 5, p. 297, December, 1874. Also printed in advance, March 26, 1874. "Well at San Diego," Pliocene. — Dall, *Proc. U. S. Nat. Mus.*, Vol. 1, p. 28, 1878. Well at San Diego. — Cooper, *Calif. State Min. Bur.*, Seventh Ann. Rept. *California State Mineral.* for 1888, p. 251, 1888. "San Diego well." Also other localities. — Orcutt, cited by Ellis in Ellis and Lee, *U. S. G. S.*, Water Supply Paper 446, p. 59, 1919. Orcutt's citation of Dall's (1874) record. Not *Modiola recta* Collignon, *Ann. Géol. Serv. Mines de Madagascar*, Vol. 16, p. 16, pl. 2, figs. 5, 6, 1949. Albian, Cretaceous, Madagascar.

Modiolus rectus Conrad, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 120, 1903. "San Diego well (Cooper): San Diego (Arnold)." "Pliocene." — Arnold, U. S. G. S., Prof. Paper 47, p. 28, 1906. "San Diego formation" at Pacific Beach, Pliocene. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 181, 1912. "San Diego-Purissima". — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 151, 1919. "San Diego", Pliocene. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1., p. 68, 1924. "San Diego well; San Diego well; San Diego". — Waterfall, Univ. Calif. Publ., Bull. Dept. Geol. Sci., Vol. 18, No. 3, opp. p. 78, 1929. "San Diego Pliocene."

Volsella recta Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 250, 1931. Cooper's record (1888), and Arnold's records (1903), cited.

Type specimen. — Location of type specimen unknown to the present authors.

Type locality. — "Inhabits sandy shores near Sta. Barbara; rare."

Range. — Late Miocene to Recent. Recent from Vancouver Island, British Columbia, to Concepcion Bay, east coast of Lower California; intertidal zone to about 46 meters (25 fathoms).

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 957, 1178, 1186, 1400, 28880, 28886, 28889, 31320. L.A.M. 103, 305, 305A. S.D. 25, 29, 408. U.C.L.A. 302.

Original description. — Shell produced, smooth, thin; anterior margin elevated; posterior side cuneiform; colour brown, with a broad pale stripe extending from the beak towards the posterior margin; within very glossy and iridescent. Length, two inches. (Conrad.)

Remarks. — Most of the specimens representing this species in collections from the San Diego Formation are imperfectly preserved. The largest specimen, a right valve from Loc. 305A (LAM), is 94 mm long and 42 mm high. The extreme anterior end is lacking but the remainder of the shell is comparable to Recent specimens of *Modiolus rectus* which lives in adjacent waters at the present time. A specimen collected by R. E. Lando, from Loc. 31320 (CAS), 68.8 mm long, also lacks the anterior portion of the shell.

Modiolus flabellatus Gould (163), considered by some authors to be a more alate form of *M. rectus* was placed in the synonymy of the latter species by Soot-Ryen.

Modiolus directus Dall (164), described from the Empire Formation of Pliocene age in Oregon, was said to differ from *M. rectus* in that "the anterior end of *M. directus* is proportionally much shorter than in *rectus*, and the posterior end still more so; the fossil is not alate above like the variety *flabellatus* Gould, and it is also more arcuate than *rectus*." Considerable variation exists in a series of specimens of *M. rectus*, Recent as well as fossil. Authors vary in their opinions concerning the taxonomic status of *M. directus*. Arnold and Hannibal (165), Howe (166) (questionably), and Grant and Gale, all placed it in the synonymy of *M. rectus*; but Etherington (167), Weaver (168), and more recently Moore, (169) treated it as a distinct species of Miocene age.

Modiolus rectus occurs rather commonly at various localities in California in beds of Pliocene age. At the present time this mollusk lives on a muddy bottom with the anterior portion embedded in a nest in the mud but

with the posterior portion of the shell exposed above the surface of the bottom. Specimens are often found which are 120 mm to 130 mm in length but huge forms are reported to attain a length of 230 mm.

Modiolus sacculifer Berry

Plate 41, Figures 2-4

Vosella sacculifer S. S. Berry, Trans. San Diego Soc. Nat. Hist., Vol. 11, No. 16, p. 407, pl. 28, figs. 1, 2, text fig. 1, September 1, 1953.

Modiolus sacculifer Berry, Soot-Ryen, Allen Hancock Pac. Exped., Vol. 20, No. 1, p. 65, text-figs. 57a-b, 58, November 10, 1958. Type locality cited. Range, "Bechers Bay, California, south to San Clemente Island, California." Recent.

Type specimen. — No. 7853, Stanford University, Department of Geology.

Type locality. — "San Pedro harbor, California."

Range. — Middle Pliocene to Recent. Recent from Monterey to Long Beach, also Bechers Bay, Santa Rosa Island, and San Clemente Island, California, from low tidal zone to 102 meters (56 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A.

Original description. — Shell of but moderate size for the genus, in outline broadly almond-shaped; highest at about the mid-point, thin, smooth, moderately inflated; hinge-line nearly straight to very slightly arcuate. Valves well rounded behind, more or less distinctly swollen ventrally in the byssal region and produced abruptly into a small obtuse lobe-like flare or pocket just under the umbones, the rounded angle of this pocket forming the anterior end of the shell; postero-dorsal area subulate, its angle obtuse. Hinge toothless except for a short, sharply conical, posteriorly directed process set off by a notch at the anterior insertion of the ligament. Periostacum light to deep brown (near Buckthorn Brown to Mummy Brown), smooth, polished, under the more or less dehiscent traces of some fairly considerable posterior shaginess. (Berry.)

Measurements. — holotype, maximum length, 38.0 mm, maximum altitude, 20.0 mm, diameter, 15.8 mm. (Berry.)

Remarks. — Several single valves, the largest 52.2 mm long, in the collections of the Los Angeles County Museum are identical with Recent specimens of *Modiolus sacculifer*. Many fragments consisting of the anterior ends of valves also are probably referable to this species.

A large Recent specimen of this species from San Pedro, California, is 57.5 mm long (beak to base), height 34 mm, convexity (both valves together), 26.4 mm.

The shell of *M. sacculifer* is readily separable from that of *Modiolus carpenteri* Soot-Ryen (170), a new name for *Modiola fornicata* Carpenter (171), in that the lobe-like anterior end extends beyond the beaks whereas in Soot-Ryen's species it does not.

Modiolus inflatus Dall (172), described from beds of Pliocene age at Coos Bay, Oregon, was later named *M. trinominatus* by Hanna (173). Dall compared his species with *M. fornicatus* [= *M. carpenteri*]. Recent specimens of *M. sacculifer* agree with Dall's illustration of *M. inflatus* except that the anterior end of the fossil is broader and the lobe-like character of the anterior extremity is not clearly observable. Dall mentioned that the

anterior end of *M. inflatus* is narrow and rounded.

Through the courtesy of Dr. G. A. Cooper, United States National Museum, we have had the opportunity to examine the type specimens of that species. It appears obvious that the preservation of the holotype is not perfect. The general outline of a virtual paratype accompanying the holotype agrees well with *M. sacculifer* but the anterior end of this specimen also is imperfect. If perfect specimens of the Oregon fossils are found showing a lobe-like, pouting anterior end, it is not unlikely that the earliest name available for the Recent species named *M. sacculifer* may be *M. trinominatus*.

GENUS GREGARIELLA MONTEROSATO

Gregariella Monterosato, Nomenclatura Generica e Specifica di alcune Conchiglie Mediterranee, p. 11, 1884. Species Cited: "*G. sulcata*, Risso (*Modiolus sulcatus*) — 1826, p. 324 (Alpi Marit.)" with synonyms, and "*G. gibberula*, Caillaud (*Modiola*) — Catal. ecc. Nantes 1865, p. 109, t. 4, 9-12 (Loire Inférieure)" with synonyms. — Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 76, 1955. Type of genus: *Modiolus sulcatus* Risso 1826 (non Lamarck 1805, 1819). — Olsson, Mollusks of the Tropical eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 128, 1961. Type species as designated by Crosse.

Botulina Dall, U. S. Nat. Mus., Bull. 37, p. 38, 1889. Sole species, "*M. opifex* Say." "Hatteras."

Trichomusculus Iredale, Proc. Linn. Soc. New South Wales, Vol. 49, Pt. 3, p. 196, October 24, 1924. "I propose the new genus *Trichomusculus*, with *barbatus* as type." P. 181, "for *Lithodomus barbatus* Reeve."

Tibialelectus Iredale, Brit. Mus. (Nat. Hist.) Great Barrier Reef Exped. 1928-29, Sci. Repts., Vol. 5, No. 6, Moll., Pt. 1, p. 424, February 25, 1939. "Type: *T. otteri*, sp. nov.", p. 424, pl. 6, fig. 24.

Type species (designated by Cross, Jour. de Conchyl., Vol. 33 (Ser. 3, Vol. 25), No. 2, p. 140, 1885). — "type: *Modiolus sulcatus*, Risso." [*Modiolus sulcatus* Risso, Hist. Nat. Europe Mérid., Vol. 4, p. 324, 1826 (not *Modiolus sulcatus* Lamarck, 1805). "Sej. Régions profondes. App. Printemps." Illustrated by Clessin, Conchyl. — Cab. von Martini und Chemnitz, ed. 2, Bd. 8, No. 3, p. 138, pl. 36, fig. 5 (as *Modiola sulcata*). — Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 4 (Pelecypoda, Fasc. 17), p. 170, pl. 29, figs. 29, 30, 31, 32, 1890 (as *Modiolaria sulcata*). See also Reeve, Conch. Icon., Vol. 10, *Modiola*, sp. 46, pl. 8, fig. 46, 1857 (as *Modiola petagnae* Scacchi).]

Range. — Miocene to Recent. Recent in from 4 to 91 meters (2 to 50 fathoms).

Description. — Shell modioliform, valves convex often angulated from the umbo to the posterior margin, beaks nearly terminal, hinge line short, posterior end attenuated; sculpture similar to that of *Musculus*, radial riblets divaricating along the medial umbonal slope, but an anterior median ventral area smooth, decussated sculpture sometimes formed when the radial riblets are crossed by thickened concentric lines of growth; posterior area covered with a brown periostracum bearing hair-like filaments and these may continue anteriorly along the central angulation; inner margin finely crenulated corresponding to the ends of the radial riblets; resilifer

narrow, often with dysodont teeth; anterior adductor large, oval. Usually burrowing forms. (Adapted chiefly from Olsson, 1961.)

Remarks. — This is the first record of *Gregariella* from the Pliocene of California. Three species now live in west American waters. Others live in the Caribbean, Mediterranean, and Indo-Pacific regions.

Gregariella chenui Récluz

Plate 41, Figures 1, 5; Plate 42, Figures 1, 8

Mytilus (modiola) chenui Récluz, Rev. Zool., Soc. Cuvierienne, Vol. 5, p. 306, 1842.

Mytilus chenuanus d'Orbigny, Voy. Amér. Mérid., Vol. 5, Moll., p. 649, pl. 85, figs. 14-16, 1846. "Elle a été recueillie au Brésil par M. Fontaine; elle se tient entre les rochers." [On explanation to plates, figs. 14-16 on plate 85 are referred to as *Mytilus fontaineanus*.]

Mytilus fontaineanus d'Orbigny, Voy. Amér. Mérid., Vol. 5, Moll., p. 710, pl. 85, figs. 14-16, 1846.

Mod. (*Gregariella*) *chenui* Récluz, Lamy, Jour. de Conchyl., Vol. 81, No. 1, p. 40, 1937. "Bahia."

Gregariella chenui Récluz, Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 78, pl. 8, fig. 40; text-fig. 65, 1955. Monterey, California, south to Bahía de la Independencia, Peru.

Modiola opifex of west American authors, not of Say, 1825.

Type specimen. — Location unknown to the present authors.

Type locality. — "Hab. les côtes du Brésil, province de Bahia."

Range. — Middle Pliocene to Recent. Recent from Monterey Bay, California to Bahía de la Independencia, Peru. (Soot-Ryen.) Also Brasil and Caribbean region, in from 2 to 91 meters (4 to 50 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305C.

Original description. — Coquille transverse, ovale, renflée, mince, marquée d'un angle obtus des sommets au bord postérieur et plane en dessus, arrondie, étroite et plus courte antérieurement qu'au côté postérieur, lequel est plus rétréci et presque anguleux. Sommets petits, saillants, obtusément arrondis, placés très-près du bord antérieur et décortiqués; l'extérieur est sculpté de très petits sillons longitudinaux, partant des crochets et rayonnant vers la base des valves: les sillons sont finement striés en dedans et ont un aspect presque onduleux; les antérieurs sont arqués et obliquent fortement en avant; les postérieurs ont une direction antérieure plus droit dans leur cours. Ces sillons et ces stries sont effacés sur le tiers antérieur des valves ou à peine apparents, et à cette place règne une dépression qui part des crochets, où elle est peu sensible et se continue en augmentant graduellement d'intensité jusqu'à la base des valves, qu'elle rétrécit légèrement dans leur longueur. La couleur de cette coquille est roussâtre, peinte longitudinalement d'une large fascie marron sur la partie déprimée et lisse. Toute la portion postérieure est couverte de poils jaunâtres, comme agglutinés entre eux, et dont les postérieurs sont disposés en trois ou quatre filaments roides, velus et saillants d'un à deux millimètres. Intérieur nacré et légèrement irisé. Charnière formée d'une série de denticules ou crenélures qui, très-saillantes antérieurement, se continuent sur toute la région supérieure des

valves, et viennent finir sur le milieu du côté postérieur, en s'affaiblissant graduellement dans leur cours. — Larg. 16, diam. 10, convex. 10 mill. (Récluz.) [A description in the Latin language also is given by Récluz.]

Remarks. — One right valve here referred to *Gregariella chenui*, 4.6 mm long and 2.5 mm high, is present in the collections of the Los Angeles County Museum from near the Mexican boundary. This is the first record of this species in the San Diego Formation.

This valve agrees in all particulars with specimens dredged off Catalina Island, California, in 55-90 meters (30-50 fathoms). The radial sculpture on both the fossil and on the Recent shells is well developed and beaded posteriorly where crossed by coarse concentric lines of growth. The largest valve in the lot from off Catalina Island is 9.4 mm long and 4.6 mm high.

This species has been cited under the names of *Botulina* or *Gregariella opifex* Say and *B. denticulata* Dall. Soot-Ryen discussed the problems connected with the correct name for this species. He accepted *Gregariella chenui* as the earliest name applicable to both the east and west American species of *Gregariella*.

The species described as *Modiolus opifex* Say (174) originally came "Amongst a number of marine shells from the island of Minorca," on "a single valve of the *Pecten nodosus*, Linn.", "attached by a broad base to the surface of the *Pecten*." The dimensions were given as "Breadth nearly half an inch; length more than one-fifth of an inch." The illustrations depict a weakly sculptured shell similar in shape to a *Gregariella*.

There appears to be no reason to doubt the locality given for this species by Say. Until evidence can be presented which definitely places Say's species as living in east American waters, it seems best to follow Soot-Ryen's decision to recognize *Mytilus chenui* Récluz as the earliest name available applicable to the east American species of *Gregariella* formerly cited as *G. opifex*. We have not had specimens of *G. chenui* from Brazil available for comparison but we have no good reason to question Soot-Ryen's identification of west American forms with that species. The reported range, however, is very great, from Brazil to Monterey, California. Olsson (1961, p. 129) mentioned that he did not find it in the Panamic region. Confirmation of the identity of the Brazilian species with the one from California is desirable.

Gregariella denticulata Dall (175) has been confused with *G. chenui* but Keen (176) recently clarified this matter and illustrated the type specimen. She described it as a pearly white shell covered with a brown to black, bearded periostracum.

The sculpture on the shell of *G. chenui* is much coarser, the posterior end more rounded and the umbonal slope is less angulated than that of *G. coarctata* Dunker in Carpenter (177). Specimens of *G. coarctata* which we have seen are larger than those of *G. chenui*.

Odhner (178) reported a species under the name of "*Modiolaria* (*Gregariella*) *opifex* Philippi" from Mas Atierra, west of Chile, in 35 to 40 meters. The maximum length of the specimens was 10 mm. We have not seen specimens from that area.

GENUS *LITHOPHAGA* RÖDING IN BOLTEN

Lithophaga Röding in Bolten, Mus. Boltinianum, p. 156,

1798. Species cited, "*L. Mytuloides*. Der Muschelartige Steinbohrer. Gmel. *Mytilus lithophagus*, sp. 6. Chemn. 8. t. 82. f. 729. 730." — Iredale, Brit. Mus. (Nat. Hist.), Great Barrier Reef Exped. 1928-29, Sci. Repts., Vol. 5, No. 6, Moll., Pt. 1, p. 416, February 25, 1939. "Haplotype: *L. mytuloides* = *M. lithophagus* Gmelin." — Cox, Mem. Geol. Surv. India, Palaeont. Indica, Ser. 9, Vol. 3, Pt. 3, p. 73, 1940. "Genotype. — *Mytilus lithophagus* Linné (1758, p. 705)". — Gardner, Geol. Soc. Amer., Mem. 11, p. 57, 1945. "Type, by monotypy: *Mytilus lithophagus* Linnaeus = *Lithodomus dactylus* Sowerby." — Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 91, 1955. "Type of genus: *Lithophaga mytuloides* Röding 1798 = *Mytilus lithophagus* Linné 1780."

Lithophagus Megerle von Mühlfeld, Gesell. Naturfor. Freunde zu Berlin, Vol. 6, Abt. 1, p. 69, 1811. Species cited, "*Lithophagus communis*."

Lithodomus Cuvier, Le Règne Anim., Vol. 2, p. 471, 1817 [December, 1816, according to Iredale, 1939]. Type designated by Sowerby (Gen. Rec. Foss. Shells, Vol. 2, No. 23, *Lithophaga*, 1824): "The type of this genus is the *Mytilus Lithophagus* of authors, which is very common in the Mediterranean, West Indies, and in all Coral rocks." Also by Herrmannsen, Indic. Malacozoor., Vol. 1, p. 611, 1847): "Typus: *Mytilus lithophagus* Linn."

Lithotornus Cuv., Schweigger, Handbuch Naturgesch., p. 712, 1820. Error for *Lithodomus* Cuvier, corrected on p. 776.

Type species (by virtual monotypy and by subsequent designation, Dall, Jour. Conch., Vol. 11, No. 10, p. 296, April, 1906). — *Mytilus lithophagus* Gmelin [= *Mytilus lithophagus* Linnaeus, Syst. Nat., ed. 10, p. 705, 1758. "Habitat in O. Indico, Europaeo, Mediterraneo, penetrans. & exedens Marmora, Corallia &." Ref. to "List. angl. 235. t. 8. f. 37", "Rumph. mus. t. 46. f. F. Pholas"; "Gault. test. t. 90. f. D.", and others. Illustrated by Chemnitz, Syst. Conch. -Cab., Vol. 8, 1785, p. 147, pl. 82, figs. 729, 730. Also by Reeve, Conch. Icon., Vol. 10, *Lithodomus*, species 9, pl. 2, fig. 9, 1857, and by Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Tome 2, p. 160, Fasc. 4 (Pelecypoda, Fasc. 17), p. 160, pl. 28, figs. 12-15, 1890. For a discussion of this species, see Dodge, H., Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 208, 1952].

Range. — ? Late Paleozoic. Late Triassic (Frech) to Recent. Recent world-wide in warm temperate and especially in tropical and subtropical waters, from intertidal zone to 91 meters (50 fathoms), rarely deeper. *Lithophaga aristata* reported from a depth of 302 meters (165 fathoms) by Soot-Ryen (1955, p. 98).

Description. — Shell sub-cylindrical, strongly inflated, elongate, not very oblique; umbones obtusely rounded, placed near or at the anterior end. Anterior end evenly rounded and inflated, posterior end rounded or tapering. Valve margins closed, without a byssal gape. Dysodont teeth absent. Ligament elongate, narrow, sub-external, supported, as in *Modiolus* and *Mytilus*, by an internal ridge which continues the antero-dorsal margin. Anterior adductor rather ventrally placed, nearly as large as the posterior one. Surface either smooth, or with fine transverse striations, or with coarse transverse ridges confined to the posterior end, or with radial ribs at the post-

erior end; or, in some species, partly coated with a calcareous incrustation. Habitat rock-boring. (Cox, 1940.)

Remarks. — *Lithophaga* is represented by but few species in beds of Tertiary age in California. Two species have been described from the Eocene, one unidentified form in the early Miocene and one species in the Pliocene. Fragments and imperfectly preserved specimens are here reported for the first time from the San Diego Formation. Nine species and subspecies, arranged in six subgenera, are recognized by Soot-Ryen as occurring in waters between southern California and Chile. Only one reaches Californian waters.

This genus is believed to be derived from *Modiolus*. The various species bore into rocks as well as into corals and thick molluscan shells. They accomplish this process by means of a specially secreted acid. This boring process has been discussed by Kühnelt (179) and by Hodgkin (180). The boring activities of *Lithophaga* and other animals in coral reefs were described by Otter (181). Verrill (182) mentioned that the shells of nearly all mollusks that bore into rocks are luminous or phosphorescent.

Lithophaga sp.

Occurrence in San Diego Fm. — L.A.M. 107, P.87.

Remarks. — Two casts from India and Upas streets, San Diego, the larger one 24.6 mm long, are present in the collections of the Los Angeles County Museum. Unornamented fragments of the interior layers of the shell also are present. The general shape of the casts corresponds fairly well with Recent specimens of *Lithophaga plumula kelseyi* Hertlein and Strong (183), of comparable size, living in adjacent waters. This form was referred by Soot-Ryen (184) to *L. subula* Reeve (185), a species described without information concerning the locality from which it came. The imperfect preservation of the fossils makes positive identification of them with *L. p. kelseyi* a matter of uncertainty. Willett (186) reported what may be this form from beds of late Pliocene age at Fifth and Hope streets in Los Angeles.

Two fragments, casts retaining occasional patches of the internal portion of the shell material, are present from Loc. 107 (LAM). The larger one, an anterior portion of the specimen is 29.6 mm long and the maximum convexity (both valves together), is 18.6 mm. The size and general shape of the two fragments bear a resemblance to *Lithophaga attenuata* Deshayes (187) but because of the incomplete state and lack of shell material we hesitate to refer these casts to any named species.

Four casts and impressions of a *Lithophaga*, retaining some of the shell material, are present in the collections of the Los Angeles County Museum but without information as to the locality from which they came. The matrix is not unlike that from Loc. 107 (LAM). The largest impression of a valve is about 55 mm long and 15 mm high. The shape is similar to that of *L. attenuata* but the preservation is too imperfect to permit identification of the species with certainty.

Berry proposed the name *Lithophaga (Labis) attenuata rogersi* (188) for a form living in the Gulf of California.

GENUS CRENELLA BROWN

Crenella T. Brown, Illustr. Conch. Great. Brit. and Ireland (189), p. 1, pl. 31, figs. 12-14, 1827. Species cited, "*Crenella elliptica* Brown" in the synonymy of which was "*Mytilus decussatus*, Laskey in Wern. Mem. 1, p. 394, pl. 8, fig. 17. — Mont. Test. Brit. Sup. p. 69." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 801, 1898. "Type *Mytilus decussatus* Montagu, 1808." — Eames, Philos. Trans. Roy. Soc. London, Ser. B, Biol. Sci., No. 627, Vol. 235, p. 370, June 26, 1951. "Type species. *Crenella elliptica* (Leach MS.) Brown, Recent = *Mytilus decussatus* Montagu, in Macgillivray; monotypy, and Stoliczka, 1871." — Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 63, 1953. "Type by monotypy; *Mytilus decussatus* Montagu."

Type species (by subsequent designation, Stoliczka, Mem. Geol. Surv. India, Palaeont. Indica, Ser. 6, Vol. 3, p. XXI, 1871). — "Typical species. *Cr. decussata*, Montg." [= *Mytilus decussatus* Montagu, Test. Brit., Suppl., Vol. 3, p. 69, 1808. "in sand on the Scottish coast." Ref. to "Chem. Conch. VIII. t. 85. f. 761?" Also illustrated by Clessin, Martini-Chemnitz Conchyl. — Cab., ed. 2, Bd. 8, Abt. 3, Mytilacea, p. 149, pl. 34, figs., 13-14, 1889. — Tebble, British Bivalve Seashells [British Museum (Nat. Hist.)], p. 48, text fig. 19a, 1966.]

Range. — Late Cretaceous to Recent. Recent in from 2 to 4188 meters (2290 fathoms).

Description. — Shell small or medium sized, sometimes minute, obliquely-ovate, convex, with small, incurved, prosogyrate beaks. Prodissoconch usually well preserved, smooth. Interior often thickened, pearly, the outer surface covered by a thin, closely adhering epidermis. Hinge mytiloid, with small tooth-like knobs on the anterior margin bordered on the posterior side by a deep, furrow-like pit for the attachment of the ligament which is wholly internal. External sculpture composed of fine radials crossed or decussated by concentrics, often divaricated along the middle line of the umbonal slope. Inner margin crenulated by the ends of the external riblets all around, sometimes extending into the hinge itself, producing a pseudotaxodont pattern. (Olsson and Harbison.)

Remarks. — Some authors have placed in the synonymy of *Crenella* the genera *Stalagmium* Conrad, *Hippagus* Lea, and *Myoparo* Lea, but Eames presented reasons for excluding these from Brown's genus. *Nuculocardia* d'Orbigny however, is generally relegated to the synonymy of *Crenella*.

The shells of *Crenella* are small and it is often difficult to separate the species. Most of the Recent species of this genus live in cool waters but a few occur in tropical waters.

Gray, 1840, placed this genus in a family Crenellidae.

Some of the species of Cretaceous and Tertiary age described under the genus *Crenella* are referable to *Arcoperna* Conrad (190). According to van de Poel (191) a shell character of *Arcoperna* which may be relied upon to separate it from *Crenella* is the presence of a narrow, smooth band which extends from the beak to the anterior ventral margin.

The shells of species assigned to the genus *Arvella* Bartsch (192) resemble *Musculus* Röding in Bolten in outline and have much broader, coarser, radial ribs than those of *Crenella*. *Botutopsis* Reis (Geogn. Jahreshfte, Bd. 39, p. 124, 1926), described from strata of Triassic

age, is believed to be a member of the *Crenella* group.

Crenella inflata Carpenter
Plate 41, Figure 11

?*Crenella inflata* Carpenter, Ann. Mag. Nat. Hist., Ser. 3, Vol. 13, p. 313, April, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 211, 1872. — K.V.W. Palmer, Bull. Amer. Paleol., Vol. 46, No. 211, p. 302, 1963. Cape St. Lucas (Xantus). "The type of *C. inflata* has not been found nor has it been illustrated."

Not *Crenella inflata* Müller, Holzapfel, Palaeontographica, Bd. 35 (Moll. Aachener Kreide, Abt. 2), p. 220, pl. 25, figs. 17, 18, 1889. [This species was originally described as *Mytilus inflatus* Müller, Monogr. der Petrefacten der Aachener Kreideformation (Bonn), p. 35, pl. 2, figs. 9, 9a, 1847. "im Grünsand bei Vael, als steinkern auch am Schindanger."]

Crenella divaricata d'Orbigny, Hertlein and Strong, Zoologica, Vol. 31, Pt. 2, p. 75, pl. 1, figs. 12, 13, 1946. "Guadalupe Island, Off Lower California, Mexico, and the Gulf of California to Ecuador." — Soot-Ryen, Allan Hancock Pac. Exped., Vol. 20, No. 1, p. 80, pl. 8, figs. 42, 44, 1955. Huntington Beach and San Miguel Island, California, to Callao, Peru. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 50, fig. 88, 1958. Southern California to the Gulf of California and south to Peru.

Not *Nuculocardia divaricata* d'Orbigny, 1842. [Referred to the genus *Crenella* by later authors.]

Type specimen. — A specimen "marked as Carpenter's type, bearing USNM Catalog Number 3998" is in the collection of the United States National Museum (J. Rosewater, written communication, November 4, 1964). Keen (written communication, October 20, 1964) mentioned that "One slide is at the B. M. labelled by Carpenter, from Cape San Lucas. The specimen is missing, apparently broken."

Type locality. — "Cape St. Lucas," Lower California, Mexico.

Range. — Middle Pliocene to Recent. Recent from Huntington Beach and San Miguel Island, California (Soot-Ryen) to the Gulf of California and south to Callao, Peru, in 4 to 91 meters (2 to 50 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A, 305C.

Original description. — ?*C. testa valde inflata, minuta, albida, subrhomboideo-orbiculari; diagonaliter parum producta; marginibus subquadrangulatis rotundatis; umbonibus prominentibus, valde antice intortis; tota superficie ut in C. decussata sculpta, costulis crebris radiantibus aequidistantibus, hic et illic aliis intercalatis; lirulis concentricis decussantibus: intus margine dorsali brevissimo, arcuato, dentato; ligamento curtissimo, in fossa omnino interna, celata, lamina definiente, sito; lamina cardinali sub umbonibus intus porrecta, dentibus validis instructa; marginibus internis omnino crenatis; cicatr. adduct. subaequalibus, ventraliter sitis. Long. .1, lat. .12, alt. .09 poll. (Carpenter.)*

Remarks. — Three specimens in the collections of the Los Angeles Museum, the largest 3 mm long and 2.3 mm wide, are here referred to the form described by Carpenter as "?*Crenella inflata*." This identification is based upon identity with specimens identified by A. M.

Strong as *C. inflata* from Cape San Lucas, the type locality of that form.

Some authors have considered *C. inflata* to be a synonym of *C. divaricata* d'Orbigny (193), originally described from Cuba, which they believed also lives in tropical west American waters.

We have not seen specimens from Cuba but we have based our conception of that species upon d'Orbigny's original description and figures, as well as upon those of other authors, which agree favorably with d'Orbigny's delineations.

Some Recent specimens from west American waters which have generally been considered to represent d'Orbigny's species, possess finer radial ribbing, less prominent concentric sculpture, and the umbos are less projecting and inflated than that of the fossil forms here referred to as *C. inflata*. Keen (1958, p. 50) considered *C. inflata* Carpenter and *C. ecuadoriana* Pilsbry and Olsson to be synonyms of *C. divaricata*.

Olsson (194), however, recently stated that "the Caribbean shell is thinner, less symmetrical in shape, usually with a larger, more conspicuous prodissococonch and with weaker sculpture." He assigned the tropical west American species referred to *C. divaricata* by Hertlein and Strong, to *C. ecuadoriana* Pilsbry and Olsson (195), a species described from strata of Pliocene age in Ecuador. Olsson recently described a subspecies, *C. ecuadoriana santiaga* (196) from strata of Miocene age in Ecuador. He also described *C. caudiva* (197), a Recent species from Ecuador, which he stated is "Distinguished easily from *C. ecuadoriana* by its unsymmetrical valves and subrhombic shape."

The fossils from the San Diego Formation bear a great similarity to some forms of *C. decussata*. Some authors have considered the west American *C. "divaricata"* to be a southern race of *C. decussata* as mentioned by Burch (198) who discussed the two species. The fossil specimens differ from typical *C. decussata* from England in the more elongately ovate shape, greater inflation, more projecting umbos and in the narrower interspaces between the radial ribs. The comparatively coarse ribbing on the fossil specimens resembles that of *C. decussata* more than it does the "*Crenella divaricata*" of west American authors. However, the relationship of the various west American species of *Crenella* is unknown and provisionally we leave Carpenter's *C. inflata* the rank of species.

ORDER ISODONTIDA DALL

SUPERFAMILY PECTINACEA RAFINESQUE (199)

Newell (200) gave a detailed discussion of the American Paleozoic groups of this superfamily.

FAMILY PECTINIDAE RAFINESQUE (201)

Shell usually of medium to large size, equivalve or inequivalve, orbicular to subtriangular, equilateral or nearly so; the valves may be alike in convexity and sculpture or they may be quite different, often slightly inflated or with one valve more inflated than the other, and may be thick or thin; monomyarian, with a single adductor muscle impression slightly posterior of the middle; beaks and umbones placed medially, usually with two triangular wings (auricles or ears), one on either side of the

umbo, the anterior one in the right valve usually with a distinct byssal sinus but this is almost lacking in some groups; surface smooth or with radial ribs or folds which corrugate the shell, sometimes with concentric lamellae; interior may be smooth or may bear radial riblets, hinge line straight, edentulous, taxodont in the very young but obsolete later, vertically striated in some groups; ligament in a central, triangular pit below the beaks, often with one or more oblique ridges of varying size diverging from it on either side; surface of upper (left) valve or both, often colored. (Adapted from Dall, Bartsch, and Rehder, Bernice P. Bishop Mus., Bull. 153, 1938, and Olsson, Mollusks of the tropical eastern Pacific, Paleo. Res. Inst.: Ithaca, New York, 1961.) Triassic to Recent, world-wide.

Remarks. — The members of this family have a wide distribution both geographically and geologically. Some swim about freely, others are attached by a byssus and rarely (as in *Hinnites*) they become sessile and irregular in form. Most of the large, coarse, thick shelled forms live in shallow temperate and tropical waters, but thin shelled usually small deep-sea forms occur in depths of at least 4504 meters (2463 fathoms).

Several thousand species of pectens have been described as fossils. About 350 to 400 species are now living in the seas, the greater number in Indo-Pacific waters. The largest forms, with the exception of species of *Patinopecten*, live in tropical marine waters. The valves of many species inhabiting temperate waters tend to be less convex and the ribs more rounded in the northern part of their range.

In some areas pectens live in great numbers. Verco (202) mentioned that off Point Marsden, Australia, at a depth of 33 meters (18 fathoms), for miles the bottom of the sea was covered with scallop shells.

The shape and sculpture of the shells of pectens, usually differing in detail on the two valves, are often quite constant, and, as mentioned by Kautsky (203), species may often be recognized from fragments. Jaworski (204) reported the observation that when riblets arise in the interspaces between the ribs of "*Vola*" [*Pecten* s. s.] they always appear first on the left valve. Dall (1898, pp. 692, 693) pointed out that when ribbing tends to become obsolete, the radial sculpture is retained on the left valve after the right valve has become nearly smooth. Furthermore, that the right anterior ear usually, is the last to lose its radial sculpture.

An interesting characteristic of the sculpture of these bivalves is that rarely, if ever, do they possess concentric ribbing although some species such as *Chlamys* (*Swiftopecten*) *swiftii* Bernardi and *C. condylomatus* Dall have concentric thickening and undulations or "ledging" (205) of the shell and others have coarse annular growth lamellae such as are present in the subgenus *Camptochlamys* Arkell. The effect of environment or other causes on the shell was well expressed by Arkell (206) who stated, "The Pectens are forms with definite and rather delicate ornament, by which small evolutionary changes may be sensitively registered." The geologic range of supraspecific units as well as of species is frequently short. Furthermore, apparently because of the composition and microstructure of the shell (which is made up of irregular foliated layers of calcite with a thin median prismatic layer of aragonite), pectens often occur abundantly as fossils where other mollusks (except some other genera such as

Ostrea) are represented only by casts and moulds. From a consideration of the features here enumerated in connection with pectens, it is obvious why this group has furnished some of the most reliable index fossils used in deciphering the age and correlation of strata.

A striking feature of the Tertiary Pectinidae, as pointed out by Davies (207), is the great increase in size during Miocene time. Most specimens from strata of Eocene or Oligocene age do not exceed 50 mm in diameter. Very large species described from the late Tertiary are: *Mizuhopecten kamagai* Nagasawa, probably of Pliocene age, in Japan, 280 mm long; *Pecten dregeri* von Teppner of Miocene age in Austria, 240 mm long; *Pecten healeyi* Arnold in the San Diego Formation, Pliocene, 222 mm long; and *Chlamys* (*Nodipecten*) *arnoldi* Aguerrevere, of late Miocene or Pliocene age in Venezuela, 218 mm long. The greatest size reported for a living species is that of *Pecten* (*Patinopecten*) *caurinus* Gould, 288 mm long and 198 mm high.

The shells of scallops were known to the ancient inhabitants of Europe. *Pecten* shells, found in caves in Europe, were used as receptacles for mixing pigments by artists of the late Paleolithic age. Pectens were known to the ancient Greeks and Aristotle studied the sense organs of some Aegean species. They were also known to early Amerindians as evidenced by Toltec carvings in the temple of Quetzalcoatl in Teotihuacán near Mexico City. The role of pecten shells in art has been mentioned by Beal (208). A book (209) published by the Shell Oil Company contains an extensive account of the history of pecten shells in the fields of history, literature, art, anthropology and industry. A scallop (*Pecten purpuratus*) reported in that work, an artifact from Chile, was dated at about 3000 B. C.

Some living species of this family especially valuable as food, have received intensive study. An interesting feature of the shell is the presence of concentric rings formed by offsets, or by color changes, during growth, and best observed on the upper valve. These rings according to Risser (210) and Gutsell (211) are a result of a quiescent period of growth during the spawning season. It is generally believed that these rings are formed annually, but this is not always the case because, as pointed out by Gutsell, rings sometimes are present on young shells which have not reached maturity. Davenport (212) discussed the significance of growth lines in fossil pectens as indicators of past climates.

Bazikalova (213) concluded from a study of *Pecten yessoensis* Jay that the rings on the valves are not reliable indicators of age. He stated that the dark rings on the whitish-yellow ground of the ligamental pit were formed annually. These he believed to be reliable indicators of the age of scallop shells as borne out by application of this method to *Chlamys laeta* [*C. nipponensis* Kuroda] and *C. swifti* as well as to *P. yessoensis*.

About 145 supraspecific units have been proposed for members of this family. Many of these have little or no taxonomic value and in some cases their use obscures interregional relationships, as shown by Fleming (214) in his studies of *Pecten* in the western Pacific region.

Many publications, only a few of which will be mentioned here, deal with scallops because of their importance and their use as guide fossils in correlation of strata and because of the commercial value of some species

for food.

Jackson (215) discussed the phylogeny of the Pectinidae and pointed out that they originated from a *Pteria*-like form. Philippi (216) also discussed their phylogeny and emphasized "iteration," the similarity of shell characters which appear again and again at different times and places in species which may not be closely related. Verrill (217) in 1897 discussed the characters and classification of the Pectinidae and the same year Sacco (218) presented a classification of the Tertiary genera and subgenera of the Mediterranean region. This was followed in 1898 by Dall (219) who reviewed the genera and subgenera of Tertiary pectens and included a review of west American Tertiary species.

A catalogue of Tertiary species and genera was published by von Teppner (220) in 1922. A number of genera and subgenera were proposed later for the New

Zealand groups by Marwick (221) in 1928, for the Recent Hawaiian species by Dall, Bartsch and Rehder (222) in 1938, and for the Recent Australian species by Iredale (223) in 1939. A number of genera proposed by Iredale have been applied to Japanese species by Habe (224).

A catalogue by Rowland (225) containing supra-specific nomenclatural units of Tertiary Pectinidae appeared in 1938.

The Cenozoic species of Pectinidae of western United States were described and illustrated in an excellent monograph by Ralph Arnold (226). A number of species from late Tertiary strata in Lower California, Mexico, were described by Hertlein (227), E. K. Jordan and Hertlein (228), and by Durham (229). Tertiary species from the eastern United States have been well illustrated and described by Tucker-Rowland (230) and by Mansfield (231).

Key to Genera and Subgenera of Pectinidae

- A. Right valve with very slight or no byssal sinus
 - a. Right valve highly convex, beak curved over hinge line *Oppenheimerpecten*
 - aa. Right valve moderately or only slightly convex, beak not decidedly curved over hinge line.
 - b. Right valve moderately convex, ribs often coarse and wide; left valve flat or concave, often with a depressed area beneath beak *Pecten* s. s.
 - bb. Right valve gently convex, ribs usually low, numerous; left valve flat or plano-convex, no depressed area beneath apex *Flabellipecten*
- B. Right valve with well-developed byssal sinus
 - a. Shell usually not exceeding 10 mm in height; no external ribs but with very fine threads or radial rows of spines or pustules *Cyclopecten*
 - aa. Shell exceeding 10 mm in height; external ribs present.
 - b. Valves with about five coarse major ribs *Swiftpecten*
 - bb. Valves with more than five major ribs.
 - c. Hinge line as long as valves or nearly so, often oblique, shell small, thin *Leptopecten*
 - cc. Hinge line shorter than valves; often large, thick.
 - d. Both valves rather flattened; very large, subcircular.
 - e. Ribs on left valve narrow, rounded *Patinopecten*
 - ee. Ribs on left valve narrow to wide, high with frill-like flanges *Lituyapecten*
 - dd. Both valves moderately or highly convex.
 - f. Valves covered with well-developed, even, radial striae; hinge with prominent cardinal crura or teeth *Lyropecten*
 - ff. Valves with spinose or imbricating sculpture; hinge with fine (or no) crura.
 - g. Adult right valve attached to substrate *Hinnites*
 - gg. Adult right valve not attached to substrate.
 - h. Left valve deeper than right; usually with spinose or imbricating sculpture; anterior ear usually longer than posterior one *Chlamys* s. s.
 - hh. Right valve deeper than left; often with imbricating but no spinose sculpture; anterior and posterior ears nearly equal in length *Argopecten*

A classic monograph of Neogene pectens of Europe begun by Depéret and Roman (232) was completed by Roger (233). A recent paper by Eames and Cox (234) deals with Tertiary pectens of Persia and the Mediterranean region and a paper by Csepregy-Meznerics (235) discusses the Neogene Pectinidae of Hungary.

The work of Grant and Gale, 1931, concerning west American species, and some of the papers of Masuda containing discussions and illustrations of Tertiary species of Japan will be mentioned in the present paper in the discussions of the species. Masuda (236) recorded and discussed 136 species and subspecies from the Tertiary of Japan, divided into twenty genera and six subgenera. A recent paper by MacNeil (237) deals with northern Cenozoic pectinids.

Recent west American Pectinidae have been discussed by Hertlein (238) and by Grau (239). Recently Olsson (240) described a new species from Peru.

Through the courtesy of Dr. F. K. North (241), a copy of a manuscript by him containing an excellent discussion of the supraspecific units of the Pectinidae was available for consultation.

A systematic arrangement of the supraspecific groups of the Pectinidae by the senior author appeared recently in "Treatise on Invertebrate Paleontology" (Part N, Vol. 1, pp. N348-N373, figs. C72-C94, 1969).

GENUS PECTEN MÜLLER

Pecten Müller, Zool. Danicae Prod., p. 248, 1776. Nine species cited including *Pecten maximus* Linnaeus. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pl. 4, p. 689, 1898. "Type *Ostrea maxima* Linné." — Depéret and Roman, Mém. Soc. Géol. France, Paléo., Mém. 26, (Tom. 10, Fasc. 1), pp. 9, 10, 1902. "Type *Pecten jacobaeus* Linné."

Janira Schumacher, Essai Nouv. Syst. Hab. Vers Test. pp. 40, 117, 1817. "pour type de ce genre j'ai donné la figure de la *Janira intermedia* Pl. III. Fig. 4."

Type species (designated by Schmidt, Versuch Conch.-Samml., p. 67, 1818). — *Ostrea maxima* Linnaeus [Syst. Nat., ed. 10, p. 696, 1758. "Habitat in Oceano Europaeo." (References include Lister, Conch., pl. 161, fig. 1; Gaultieri, Test., pl. 98, figs. A. B.; and others). Also illustrated by Reeve, Conch. Icon., Vol. 8, *Pecten*, sp. 38, pl. 9, fig. 38, 1852. — Dakin, Liverpool Mar. Biol. Comm., Mem. 17, *Pecten*, pl. 1, figs. C, D, E, F, 1909. See also discussion of this species by Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 163-164, 1952].

Range. — Late Eocene to Recent, worldwide in warm temperate and tropical marine water. Late Oligocene or early Miocene to Recent in western North America and in the Tethyan region; Pliocene to Recent in New Zealand, Australia, East Indies, Philippine Islands and Japan (242). Recent in from 9 to 1846 meters (5 to 919 fathoms).

Description. — Shell suborbicular, often large, inequivalve; right valve convex, the left flat, concave or slightly convex; auricles moderately large, nearly equal, delimited from body of shell, a slight byssal sinus, usually only slightly developed, under the anterior auricle; ctenolium lacking; sculptured with rather broad, square or rounded radial ribs which may bear longitudinal threads or may be nearly smooth, and the whole crossed by fine concentric imbricating lamellae; in some subgenera (such

as *Euvola*) the radial sculpture consists of grooves; 2 to 4 pairs of cardinal crura radiate from the top of the ligamental pit; inner margin of ventral portion of valves usually scalloped corresponding to the exterior ribbing.

Remarks. — Deshayes (243) discussed the early usage of the name "*Pecten*" and Lovell (244), Stearns (245), and others have discussed the historic and heraldic significance of certain species of this group of bivalves, especially in Europe.

The usage of the generic name *Pecten* by Osbeck, 1765, accepted by Grant and Gale, 1931, is considered to be a *nomen nudum* by most authors. Reasons for that conclusion are clearly expressed by Stiles (246).

Pectens with convex right and flat or concave left valves occur early in the Jurassic of North and South America, and somewhat similar forms occur in the Mediterranean region. Cox (247) recently reviewed the opinions of some of the earlier authors concerning the classification of Mesozoic pectens. The early Jurassic forms are referable to genera such as *Weyla* J. Böhm (type, *Pecten alatus* von Buch) which possess hinge characters different from modern forms. We are inclined to restrict the use of the genus name *Pecten* to Cenozoic species.

Twenty-four species and subspecies of pectens with concave-convex valves have been described from the late Cenozoic in the region between California and Peru, three of which occur in the San Diego Formation. The earliest representative in this region is *Pecten sanctaecruzensis* Arnold (248) from strata of early Miocene age. This species bears a general resemblance to *P. valentinensis* Fontannes (249), from the Burdigalian, early Miocene of Europe.

Most recent species of *Pecten* can swim freely by clapping their valves together. By expelling the water rapidly from the body cavity, they are capable of executing a series of zig-zag movements, the ventral margin foremost. However, when frightened by an enemy or for any other reason, they can swim backward with the hinge foremost. When at rest they lie upon the right valve on the floor of the ocean. A row of bright eyes occurs along the edge of the mantle and with these organs the scallop can detect light and shadow.

The rate of growth varies with different species. Dakin (250) made an extensive study of *Pecten maximus* and found that shells 86 mm in anterior-posterior diameter were 3 1/2 years old. Fleming (251) mentioned that growth of Recent scallops declines rapidly after three years but that some may attain an age of 22 years. The same author gave an excellent discussion (252) of the western Pacific species of the genus *Pecten* and their interregional relationships.

SUBGENUS PECTEN S. S.

Pecten (*Pecten*) *bellus* Conrad

Plate 30, Figures 1, 2, 3, 4, 9;

Plate 32, Figure 14; Text figure 7

Janira bella Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 8, p. 312, December, 1856. Reprint by Dall, U. S. G. S., Prof. Paper 59, p. 173, 1909. — Conrad, U. S. Pac. Rail Road Expl., Vol. 6, Pt. 2, No. 2, p. 71, pl. 3, fig. 16, 1857. "Locality. — Santa Barbara, Cal. — Doctor Newberry." — Orcutt, West Amer. Sci., Vol. 6, whole No. 45, p. 70, July, 1889. "Pacific Beach,"

- "Tertiary." — Keen and Bentson, *Geol. Soc. Amer., Spec. Papers* No. 56, p. 55, 1944. Earlier records cited.
- Pecten Hemphilli* Dall, *Proc. U. S. Nat. Mus.*, Vol. 1, p. 15, 1878. "San Diego." "Later Tertiaries." — Dall, *Proc. U. S. Nat. Mus.*, Vol. 1, p. 29, 1878. "About ten miles northward from San Diego, on the seacoast of California." — Carson, *Pan-Amer. Geol.*, Vol. 43, No. 4, p. 268, 1925. "San Diego fauna." Pliocene.
- Pecten hemphilli* Dall, Cooper, *Calif. State Min. Bur., Seventh Ann. Rept. State Mineral.*, Vol. 7, p. 257, 1888. "Pl. — San Diego." — J. P. Smith, *Calif. State Min. Bur., Bull.* No. 72, p. 38, 1916. "San Diego and lower Fernando formations of the coastal region of southern California." — J. P. Smith, *Proc. Calif. Acad. Sci.*, Ser. 4, Vol. 9, No. 4, pp. 146, 150, 151, 155, 1919. "San Diego," Pliocene. Also "Fernando" and "Santa Maria faunal zone," Pliocene. — Keen and Bentson, *Geol. Soc. Amer., Spec. Papers* No. 56, p. 87, 1944. Dall's original record cited. Also others. — Woodring, in Woodring and Bramlette, *U. S. G. S., Prof. Paper* 222, pp. 64, 82, pl. 16, figs. 15, 16; pl. 21, fig. 8, 1950. Cebada and Graciosa members of the Careaga Sandstone, Santa Maria district; p. 104, Pacific Beach and inland, San Diego district; p. 106, "San Diego formation." — Vedder, *U. S. G. S., Prof. Paper* 400-B, p. B327, 1960. "San Diego formation at Pacific Beach." Also Niguel Formation and localities in southern California and Lower California.
- Pecten (Pecten) hemphilli* Dall, *Trans. Wagner Free Inst. Sci.*, Vol. 3, Pt. 4, p. 706, 1898. "Found with *P. expansus*" [= *P. healey* Arnold]. — Schuchert, Dall et al. *U. S. Nat. Mus., Bull.* 53, Pt. 1, p. 488, 1905. "Pliocene. San Diego, California."
- Pecten (Pecten) hemphilli* Dall, Arnold, *Mem. Calif. Acad. Sci.*, Vol. 3, p. 105, 1903 (as *Pecten hemphilli*, p. 63). "Pliocene. — Pacific Beach and Russ School, San Diego (Hemphill; Dall; Arnold)." — Arnold, *U. S. G. S., Prof. Paper* 47, pp. 28 (as *P. hemphilli*), 97, pl. 33, figs. 3, 3a, 3b, 1906. "Pacific Beach, Russ School, and 'San Diego well', San Diego," Pliocene. Also in Temescal Canyon north of Santa Monica, California. — Arnold and Anderson, *U. S. G. S., Bull.* 322, pp. 59, 152 (as *Pecten hemphilli*), pl. 25, fig. 5, 1907. "One mile north of Schumann station", also from "Fernando" of Santa Maria district, Pliocene. — Keen and Bentson, *Geol. Soc. Amer., Spec. Papers* No. 56, p. 87, 1944. Arnold's records cited, also others. — Glibert and Van de Poel, *Mém. Inst. Roy. Sci. Nat. Belgique*, Deuxième Ser., Fasc. 78, p. 19, 1965. Pacific Beach, San Diego, Pliocene.
- Pecten (Pecten) bellus* Conrad, Arnold, *Mem. Calif. Acad. Sci.*, Vol. 3, p. 103, pl. 21, figs. 1, 2, 1903. "Pliocene at Santa Barbara, California." — Arnold, *U. S. G. S., Prof. Paper* 47, p. 95, pl. 31, figs. 1, 1a, 1906. Various localities in late Pliocene of southern California. — Arnold, in Arnold and Eldridge, *U. S. G. S., Bull.* 309, p. 24, pl. 35, fig. 3, 1907. "Pliocene, Santa Barbara. Also found in Pliocene of Ventura, Santa Barbara, and adjacent Counties." — Arnold, *U. S. G. S., Bull.* 321, p. 32, pl. 15, figs. 1a, 1b, 1907. "Bathhouse Beach, Santa Barbara." "Packards Hill" (p. 32). — E. K. Jordan and Hertlein, *Proc. Calif. Acad. Sci.*, Ser. 4, Vol. 15, No. 14 pp. 417, 430, pl. 32, fig. 2; pl. 33, figs. 1 and 2; pl. 34, figs. 2, 3, 4, 1926. "Pacific Beach near San Diego, California", Pliocene. Also other localities in southern California and Lower California.
- Pecten bellus* Conrad, McLaughlin and Waring, *Calif. State Min. Bur., Bull.* No. 69, map folio (inside back cover), sp. No. 46, pl. 1, fig. No. 46, 1914. "Fernando of the Santa Clara River Valley, Ventura Co., California." — J. P. Smith, *Proc. Calif. Acad. Sci.*, Ser. 4, Vol. 9, No. 4, pp. 150, 152, 1919. "San Diego," Pliocene. Also "Fernando" and "Santa Barbara," Pliocene. — Clark, *Stratigraphy and Faunal Horizons of the Coast Ranges of California* (Privately Publ.), p. 28, pl. 40, figs. 1, 2, 1929. Middle and Upper Pico, Pliocene (cited as "*Pecten (Pecten) bellus* Conrad" on expl. to plate 40). — Hertlein and Grant, *Jour. Mines Geol.*, Rept. 35 of *Calif. State Mineral.*, p. 69, 1939. Sandstone overlying basal conglomerate, Pacific Beach, Pliocene. — Hanna and Hertlein, *Calif. State Div. Mines, Bull.* 118, p. 176, fig. 14 (p. 177), 1941. "Base of Santa Barbara sands and marls on trail on northeast slope of Packard's Hill, Santa Barbara, California." "Upper Pliocene". — Hertlein and Grant, *Mem. San Diego Soc. Nat. Hist.*, Vol. 2, Pt. 1, pp. 56, 59, 1944. Upper beds exposed in Pliocene section at Pacific Beach; also near Mexican Boundary 3/4 mile from the sea. — Hertlein and Grant, *Calif. State Div. Mines, Bull.* 70, Chapt. 2, p. 60, 1954. San Diego Formation, Pliocene. — Milow and Ennis, 57th Ann. Mtg. Cordilleran Sec., *Geol. Soc. Amer., Field Trip Guidebook* — 1961, San Diego Co., 1961, p. 28. "San Diego formation."
- Pecten (Janira) bellus* (Conrad) variety *hemphilli* Dall, Grant and Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, p. 226 [not all the synonymy], pl. 3, figs. 1a, 1b, 1931. "Middle Pliocene at Pacific Beach, San Diego." Also other localities.
- Pecten bellus hemphilli* Dall, Woodring, Stewart, and Richards, *U. S. G. S. Prof. Paper* 195 (table opposite p. 112), 1941. "Strata at Pacific Beach." Also mentioned, p. 111.
- Pecten (Pecten) bellus hemphilli* Dall, Moore, *San Diego Soc. Nat. Hist.*, Occas. Paper 15, p. 50, pl. 23, figs. c, d, 1968. San Diego Pliocene. Also other localities.
- Type specimen. — Originally in Academy of Natural Sciences of Philadelphia. Specimen now missing.
- Neotype specimen (designated by Stewart, *Acad. Nat. Sci. Philadelphia, Spec. Paper* No. 3, p. 117, 1930. "The specimen described and figured by Arnold (1906, p. 95, pl. 31) is taken for the neotype of this species." "Pliocene, Santa Barbara, Cal."). — No. 960, Academy of Natural Sciences of Philadelphia.
- Type locality. — "Locality. — Santa Barbara, Cal. Doctor Newberry."
- Range. — Middle and late Pliocene; southern California and northern Lower California. Santa Cruz Island, California; Cedros Island, Lower California.
- Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 104, 105, 547, 957, 1130, 1138, 1178, 1199, 1400, 1402, 2020, 28453, 28644, 28884, 28886, 28889, 28892, 31356, 1141, 1155, 1176, 1177, 36599. L.A.M. 107, 122, 124, 127, 180, 302, 205, 305A, 308, 309, A-2081. S.D. 20, 23, 29, 37, 150, 413, 417. S.D.S.C. 31, 32, 47. U.C.L.A. 296, 307, 1382, 1386, 2420.

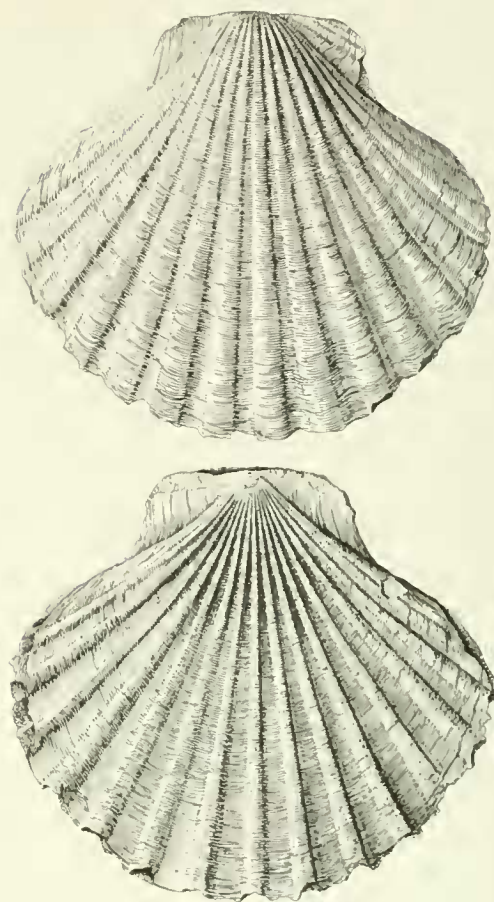
Original description. — Subtriangular; inferior valve convex, ribs 14 or 15, square, about as wide as the intervening spaces, very prominent, some of them with one or two longitudinal obsolete lines; disk finely wrinkled concentrically; upper valve flattened, deeply depressed toward the apex; ribs rather narrower than those of the opposite valve, obscurely bicarinated above, disk ornamented with close, fine, squamose, concentric wrinkles. Length 4 inches; height 3 3/4 inches. (Conrad.)

Description of neotype. — Shell large, thin, inequivalve, elegantly, radiately ribbed. Left (upper) valve slightly convex, the point of greatest convexity being generally about one-fourth the distance from the apex toward the ventral margin; between this point of greatest convexity and the apex there is a deeply depressed area, the depression generally not affecting the two outer ribs on each side, which inclose the depression on the sides; surface of left valve ornamented with 13 or 14 prominent, flat-topped, sometimes faintly bicarinated, radiating ribs, which have flat, sloping sides; these ribs become broader, less elevated, and less sharply angulated near the periphery in the adult; interspaces slightly wider than the tops of the ribs, with slightly rounded bottoms; whole surface of left disk covered with fine, sharp, concentric, regular lamellae; ears rather small, subequal, slightly concave, finely concentrically lamellated, separated from the disk by an impressed line. Right (lower) valve prominently convex, the point of greatest convexity being about one-third the distance from the apex to the ventral margin of the disk; the umbo in this valve curves sharply and meets the plane of the ears at an angle of about 90 degrees; surface of right valve ornamented by 14 or 15 prominent, nearly flat-topped, square, radiating ribs, some of them with one or two longitudinal obsolete lines; the ribs become somewhat less elevated and the sides more sloping as the periphery is approached in the adult; surface of right disk ornamented with close, fine, squamose, concentric wrinkles; ears subequal, arched, covered with crowded, elevated lamellae; byssal notch small. Alt. 80 mm.; lat. 108 mm.; diam. 32 mm.; length of hingeline, 45 mm. (Arnold.)

Remarks. — Fossils here referred to *Pecten bellus* occur at nearly every locality where Pliocene fossils are found in the San Diego area.

We have examined over 600 specimens, the greater number single valves, varying in size from 8 mm to 78.8 mm high. The number of ribs vary from 12 to 18 but the average is about 15. The ribs on the ventral portion of large forms tend to become broad, flat-topped, the sides slope rather steeply to the interspaces. The ribs on smaller specimens are higher, narrower and more rounded. The tops of ribs on large specimens sometimes bear one or more faint longitudinal grooves. The ribbing on the interior of valves, which is well defined on the right valve, extends to the umbonal area, on the left valve to the muscle impression. Low flanges are present on the ribs near the ventral margin of large valves. There are usually two pairs of rather weakly developed cardinal crura but these are not prominent. Auricular crura are well developed on the left valve but less pronounced on the right valve.

Pecten hemphillii Dall was described from beds of Pliocene age at San Diego and compared with *Pecten slearnsii* rather than with *Janira bella* Conrad. Several authors have considered *P. hemphillii* and *P. bellus* to



Text Fig. 7. *Pecten (Pecten) bellus* Conrad. Hypotype (Cat. No. 2408, University of California at Los Angeles), from Pacific Beach, San Diego; Pliocene. Length 63 mm. A. Right valve. B. Left valve. (Drawn by E. H. Quayle.)

represent the same species. E. K. Jordan and L. G. Hertlein accepted this viewpoint. Grant and Gale cited *P. hemphillii* as a variety of *P. bellus* and stated (p. 886, pl. 3, fig. 1a), "This variety is practically indistinguishable from the typical variety." Woodring, in a recent paper (1950), considered the two forms to be closely related but separable, with *P. hemphillii* being smaller and not exceeding 60 mm in height. We have had available for study five specimens collected by Henry Hemphill and labelled by him "*Pecten hemphillii* Dall. Original lot. Pacific Beach, Cal. San Diego." The largest of these, No. 526a (Calif. Acad. Sci. Dept. Geol. Type Coll.), is 88 mm long, 78.8 mm high, convexity (both valves together), 24 mm. The ribs at the ventral margin are 7.5 mm wide (see plate 30, figures 4 and 9). This specimen, in all shell characters, is similar to specimens of *P. bellus* collected by Tom Dibble at Packard's Hill, Santa Barbara, California, and by others in that area.

The other four specimens from the original lot of *P. hemphillii* vary as to the width of the ribs. Two show a decided widening toward the ventral margin, the ribs of the other two remain quite narrow and with vertical sides for their entire length. A large right valve collected by G. P. Kanakoff at Loc. 107 (LAM) at the end of Arroyo

Drive, San Diego, is 86 mm long and 77.5 mm high. This specimen in ribbing and other shell characters resembles *P. bellus*. It is true that very large specimens from strata of late Pliocene age at Santa Barbara and other localities attain a greater size. Conrad's type specimen was described as 4 inches (approximately 101 mm) long, and Gabb's specimen illustrated by Arnold and designated as a neotype by Stewart is 108 mm long and 80 mm high. The largest specimen from the San Diego Formation observed by us is 88 mm long and 78.8 mm high. Arnold stated that specimens to a height of 20 mm are hardly separable into two species. A study of the specimens before us seems to indicate that the chief difference between *P. bellus* and *P. hemphilli* is that the former may attain a greater size. However, large specimens from the San Diego Formation apparently do not differ in any constant shell characters from *P. bellus*. We therefore agree with the conclusion of E. K. Jordan and Hertlein who considered *P. bellus* and *P. hemphilli* specifically identical, and stated concerning the latter, "The type of *P. hemphilli*, as indicated by the illustration furnished by Arnold, is an intermediate form not exactly similar to either extreme of the series, although it inclines toward the narrow-ribbed variants."

This opinion is supported by the observations of Drucker (253) who examined more than 80 specimens of the *P. bellus-hemphilli* series. These varied from 19 to 130 mm in length, average 57 mm; 17 to 99 mm in height, average 51 mm; umbonal angle 89° to 107°, average 97°; right valve with 12 to 17 ribs, average 15; left valve with 11 to 16 ribs, average 14. He concluded that "as the relations of the two forms remain moot, they are arbitrarily placed in synonymy."

Two specimens from Pliocene strata on the east coast of Lower California were illustrated by Durham (254) under the name of *P. bellus* var. *hemphilli*. The right valve, 77.5 mm long (incomplete), differs from *P. bellus* in the proportionately larger and only slightly convex ears and in the general character of the radial ribs. The left valve, 126.5 mm long, with traces of a midrib in the interspaces and finely radially sculptured ears is not typical of *P. bellus* but somewhat resembles the corresponding valve of one of the *P. bakeri* group, perhaps *P. bakeri diazi* (255). Vokes (256) mentioned the occurrence of a fossil form which he considered to be an undescribed subspecies of *P. bellus* bearing 22 ribs from the Infierno Formation of late Pliocene age in the Santa Rosalia area, Lower California.

The species described as *Pecten (Pecten) auburyi* Arnold (257) appears to be only a variant of *P. bellus*. We have examined a paratype, a right valve, slightly distorted (No. 78, Calif. Acad. Sci. Dept. Geol. Type Coll.), from the type locality in Puente Hills in Los Angeles Co. It is 47.6 mm long and 41.8 mm high. It has rather narrow ribs similar to those on the earlier stages of *P. bellus* and is inseparable from some forms labelled *P. hemphilli*.

Pecten (Pecten) lecontei Arnold (258) described from Cedros Island, Lower California, is quite distinct from *P. bellus* and its variants. The ribs, about 18 on the right valve and 17 on the left, are round-topped. Those on the right valve usually quite smooth, separated by flat-bottomed interspaces which are narrower than the ribs. The left valve is usually slightly concave and the rounded ribs are quite different from the high usually flat-topped ribs of *P. bellus*.

Pecten (Pecten) slevini Dall and Ochsner (259) described from strata of Pliocene age on the Galápagos Islands differs from *P. bellus* and its variants by the narrower, rounded ribs on the right valve which are separated by wider interspaces, and by the wider apical angle. The specimen which Grant and Gale (260) illustrated as *P. bellus* var. *slevini* from beds of Pliocene age in Los Angeles Co. appears to be quite different from the type of *P. slevini*, the chief feature of similarity being the wide apical angle. It is probably a distorted specimen of *P. bellus*. Illustrations of *P. archon* Maury (261) bear a resemblance to *P. slevini* but that Miocene Caribbean species has fewer ribs, which on the right valve are shallowly bifid toward the ventral margin.

The shell of *Pecten bellus* bears a general resemblance to that of *P. albicans* Schröter (262) and to *P. excavatus* Anton (263), which have fewer ribs, but close relationship with these Japanese species has not been demonstrated.

Some authors have suggested that *Pecten bellus* could be placed in the supraspecific group named *Notovola* by Finlay. Fleming (264), however, stated that *Notovola* "has no phylogenetic unity," that relationship exists between relatives of the type species, *P. novaezelandiae* Reeve, and the Mediterranean species *P. jacobaeus* which is referable to *Pecten* s. s. and that Finlay's genus is an unwarranted supraspecific unit.

SUBGENUS FLABELLIPECTEN SACCO

Flabellipecten Sacco, Bol. Mus. Zool. e Anat. Comp. (Torino), Vol. 12, No. 298, p. 102, June 11, 1897. — Sacco, Moll. Terr. Terz. Piemonte e Liguria, Pt. 24, p. 55, December, 1897. "tipo *F. flabelliformis* (Br.)." — Depéret and Roman, Mém. Soc. Géol. France, Paléo., Tom. 18, Fasc. 2 (Mém. No. 26 (suite), p. 105, 1910. — Cossman and Peyrot, Act. Soc. Linn. de Bordeaux, Vol. 68 (Conch. Néogène l'Aquitaine, Tom. 2, Livr. 2), p. 272, 1914. "(G. T. *Pecten flabelliformis* Brocchi, Plioc.)." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 159, 1961. "type species by original designation and tautonymy, *F. flabelliformis* Brocchi."

Type species (by original designation). — "*Flabellipecten flabelliformis* (Br.) (tipo del nuovo sottog.)." [= *Ostrea flabelliformis* Brocchi, Conch. Foss. Subapennina, Vol. 2, p. 580, 1814. "Fosile nel Piacentino e in Valle di Andona." Pliocene. Illustrated by Depéret and Roman. Mém. Soc. Géol. France, Paléo., Tome 1, Fasc. 1, (Mém. No. 26 (suite)), p. 139, pl. 19 (Mém. 26, pl. 18), figs. 1, 1a, 2, 1912. "Topotype de l'Astien du Val d'Andona près Asti (Italie)." — Ronchetti, Riv. Ital. Paleo. e Strat., Mém. 5, Pt. 1, p. 30, fig. 10a, b, c, 1952. [Illustration of type specimen.]

Range. — Early Miocene (Aquitainian) to late Pliocene in the Mediterranean region; (265) Miocene (late and perhaps middle) and Pliocene in the Caribbean region; Middle Miocene to Recent in North and Central America.

Description. — Shell large or of medium size and thickness, apical angle wide. Right valve only moderately convex, the umbo slightly incurved; sculpture commonly consisting of numerous, low, often rounded (but occasionally squarish) radial ribs which are smooth on top or occasionally shallowly longitudinally grooved, the ribs

separated by narrower interspaces; ears subequal, a slight byssal notch at the base of the right ear. Left valve flat or plano-convex; the ribs narrower and the interspaces wider than those on the right valve and often bearing an interstitial thread. Exterior of both valves crossed by fine imbricating lines of growth. Hinge with two to four cardinal crura. The radial flutings on the interior extend inward from the ventral margin about one third the length of the valves. (Adapted from Depéret and Roman, and from Olsson.)

Remarks. — *Flabellipecten* differs from *Pecten* s. s. in the less highly arched right valve which is only slightly incurved at the apex, greater apical angle, smaller ears, more numerous and usually lower radial ribs and in that the left valve is flat or slightly convex and lacks a depression in the umbonal region.

Some American species from time to time have been referred to *Flabellipecten*. Toulou (266) in 1908 placed *P. gatunensis*, described from beds of Miocene age in Panama, in *Flabellipecten*, and Depéret and Roman in 1912 mentioned that "*Fl. floridus*" [= *P. diegensis* Dall] was a member of the *Flabellipecten* group. Hertlein (1935, p. 303) mentioned the similarity of *P. diegensis* to the European Miocene species, *P. fraterculus* Sowerby, and to the *P. bessi* group, and also called attention to several similar east American species. Recently Olsson (1961, p. 159) placed in this category, *P. gatunensis* and *P. macdonaldi* Olsson, both species of Miocene age in Central America, and *P. sericeus* and *P. diegensis*, Recent west American species. Roger (1939, p. 264) mentioned the great number of species of *Flabellipecten* in the Atlantic region and intimated the possible origin of this group in the Americas.

Species such as *P. gatunensis*, *P. macdonaldi*, *P. bösei*, *P. sericeus*, and *P. diegensis* bear a close resemblance to species assigned to *Flabellipecten* by European authors. *Pecten hawleyi* Hertlein (267), from the early Miocene (Vaqueros Formation) of California, may be a member of this subgenus. Other species such as *P. stearnsii* Dall, *P. carriazoensis* Arnold and *P. beali* Hertlein, described from strata of Pliocene age in southern California and Lower California, differ from the type species of *Flabellipecten* in the fairly high, medially sulcated ribs but they are believed to be allied to *P. diegensis* and should be included in the same supraspecific taxonomic category. Several east American species of late Cenozoic age are members of this same group, including *P. soror* Gabb, from the Miocene of Santo Domingo, *P. soror codercola* Harris, from the late Tertiary of Venezuela, *P. ochlockoneensis* Mansfield and *P. ochlockoneensis violae* Tucker, from strata of Miocene age in Florida and *P. hemicyclus* Ravenel from beds of Pliocene age in South Carolina.

Some of the American species here referred to *Flabellipecten* differ considerably from the type species of *Flabellipecten* in the character of the ribbing and especially in the fewer cardinal crura. These shell characters, however, vary in the numerous fossil forms described from the Mediterranean region which have been assigned to *Flabellipecten*.

This American group could be placed in a new subgeneric category but we hesitate to add another supraspecific unit for these species whose shell characters so closely resemble species of the *Flabellipecten* group. Furthermore, the taxonomic value of such a new subgeneric

unit would be questionable, especially if the statement of Depéret and Roman (1910, p. 107) (268) is taken into consideration, that shell characters of some species reveal gradation of *Flabellipecten* into *Pecten* s. s.

Pecten (Flabellipecten) stearnsii Dall

Plate 29, Figures 2, 4; Plate 35, Figure 10; Text Figure 8

Janira florida Hinds, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, December, 1874. (Printed separately March 26, 1874). "well at San Diego," "Pliocene." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. Well at San Diego. — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., Vol. 7, p. 244, 1888. "Pl. — San Diego well."

Not *Pecten floridus* Hinds, 1844 = *Pecten diegensis* Dall, 1898.

Not *Ostrea florida* Gmelin, 1791, a *Pecten*.

Pecten stearnsii Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 14, March 27, 1878. "Later Tertiary of San Diego." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 29, 1878. "About 10 miles northward from San Diego, on the seacoast of California," "(stratum C)." — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 258, 1888. "Pl. — San Diego." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, pp. 150, 151, 1919. "San Diego," Pliocene. — Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 222, p. 104, 1950. Pacific Beach and inland, San Diego, Pliocene. — Hertlein and Grant, Calif. State Div. Mines, Calif. Jour. Mines Geol., Rept. 35 of State Mineral., pp. 69, 70, 1939. "In the massive yellowish and gray sandstone overlying the basal conglomerate" "at Pacific Beach," south slope of Mount Soledad, and "Along India Street," San Diego. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 56, 1944. "Pacific Beach," p. 57, "south sloping spurs of Mount Soledad," p. 59, "excavations along India Street, particularly at the corner of Upas Street." — Keen and Bentson, Geol. Soc. Amer. Spec. Papers No. 56, p. 94, 1944. Earlier records cited. — Hertlein and Grant, Calif. State Div. Mines, Bull. 170, chapter 2, p. 60, 1954. "San Diego formation." Pliocene.

Janira dentata Sowerby, Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., Vol. 7, p. 244, 1888 (in part). "Pl. — San Diego well."

Not *Pecten dentatus* J. Sowerby, 1829, nor *Pecten dentatus* G. B. Sowerby, 1835.

Pecten (Pecten) stearnsii Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 706, pl. 26, fig. 5, 1898. "With *P. expansus*" [i.e. "Pliocene of Pacific Beach (lower horizon), near San Diego, California." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, pp. 63 (as *Pecten stearnsii*), 106, pl. 12, fig. 3, 1903. "San Diego (Pacific Beach, lower horizon)." — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. 53, Pt. 1, p. 490, 1905. "Pliocene. San Diego, California." — Arnold, U. S. G. S., Prof. Paper 47, pp. 28 (as *Pecten stearnsii*), 100, pl. 32, figs. 1, 1a, 1906. "Pacific Beach, near San Diego." — Arnold in Eldridge, U. S. G. S., Bull. 309, pp. 242, 244, pl. 35, fig. 2; pl. 36, fig. 4, 1907. "San Diego formation (Pliocene), Pacific Beach, San Diego County." — Arnold and Anderson, U. S. G. S., Bull. 322, pp. 59, 152, pl. 25, figs. 1a, 1b, 1907. "San Diego formation

(Pliocene), Pacific Beach, San Diego County, Cal." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. San Diego well [Dall's record of "*Janira florida*, Hds."]; p. 56 (as *Pecten stearnsii*, "Pacific Beach," p. 57 (as *Pecten stearnsii*), "south sloping spurs of Mount Soledad," p. 59 (as *Pecten stearnsii*), "excavations along India Street, particularly at the corner of Upas Street," San Diego. — Milow and Ennis, 57th Ann. Mtg. Cordilleran Sec., Geol. Soc. Amer., Field Trip Guidebook San Diego Co. 1961, p. 28, 1961. "San Diego formation." Pliocene. — Glibert and Van de Poel, Mém. Inst. Roy. Sci. Nat. Belgique, Deuxième Sér., Fasc. 78, p. 21, 1965. Pacific Beach, San Diego, Pliocene (as *Pecten* (s. s.) *stearnsii*). — Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 48, pl. 22, figs. a, b, 1968 (as *Pecten* (*Pecten*) *stearnsii*). Pacific Beach, Pliocene.

Pecten cf. *P. diegensis* Dall, Dall cited by Ellis, in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 63, 1919. Fossil Canyon, about 3 1/4 miles east of Chula Vista and 1 1/4 miles southeast of Bonita. "Upper Miocene." [Pliocene.]

Pecten (*Janira*) *stearnsii* variety *stearnsii* Dall, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 223, pl. 3, figs. 1a, 1b (Holser Canyon), 1931. "Pliocene: Pacific Beach, San Diego." Earlier records cited.

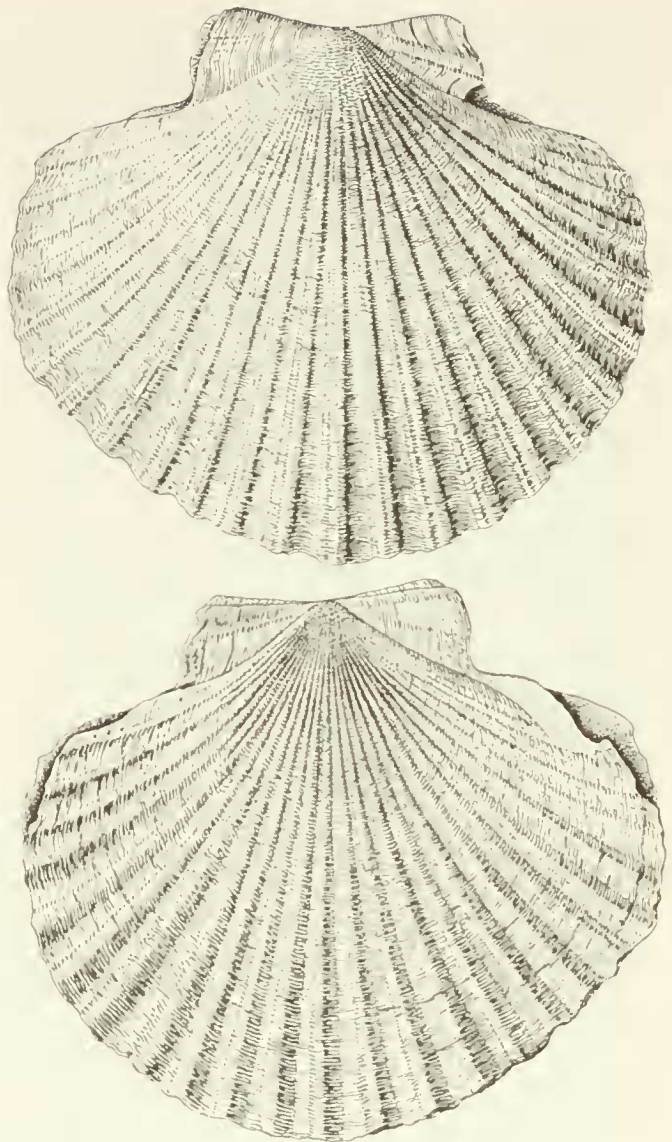
Type specimen. — No. 7942, United States National Museum.

Type locality. — "well at San Diego," California. "Pliocene."

Range. — Middle to late Pliocene (possibly to early Pleistocene).

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 104, 105, 547, 1132, 1138, 1181, 1182, 1183, 1186, 1199, 1399, 1401, 1404, 1413, 1414, 1415, 2015, 28644, 28885, 28889, 28893, 33334, 35025. L.A.M. 107, 121, 122, 180, 305, 309, 1178, A-1323. S.D. 2, 4, 5, 75, 80, 88, 331, 404, 417. U.C.L.A. 294, 295, 299, 300, 312, 2359, 2407, 2420.

Original description. — Shell moderately large, thin, regular; elegantly radiately ribbed. Upper valve flattened or even a little concave, with about twenty-four regularly rounded, vaulted, even ribs, separated by slightly wider channelled interspaces; the whole surface covered with fine, sharp, concentric, regular lamellae, a little looped backward over the top of the ribs, but showing no appearance of reticulation anywhere; ears small, nearly symmetrical, covered with more elevated, crowded, concentric lamellae, especially near the margins; hinge-margin straight, or even a little concave toward the umbo; peripheral margins of the valves strongly and regularly crenulated and interlocking; interior regularly deeply grooved, to correspond with the external ribs; lower valve slightly convex, with about twenty-six regular even ribs, separated by channelled interspaces somewhat narrower than the ribs; the top surface of each rib is flattened with a broad, shallow groove in the middle, with one or two faint riblets on each side of the groove; the whole surface is covered with concentric lamellae, like those of the upper valve, but less sharp, and about twice as crowded. Ears subequal, arched, covered with crowded, elevated lamellae; byssal notch very small. Height of shell, 90 mm; breadth, 100 mm; breadth of hinge-line, 34 mm; thickness, 15 mm. (Dall.)



Text Fig. 8. *Pecten* (*Flabellipecten*) *stearnsii* Dall. Hypo-type (Cat. No. 2407, University of California at Los Angeles), from Pacific Beach, San Diego; Pliocene. Length 105.6 mm. A. Right valve. B. Left valve. (Drawn by E. H. Quayle.)

Remarks. — This species occurs rather abundantly at various localities including the beds in the upper portion of the Pliocene section at Pacific Beach, also on the south slope of Mount Soledad and on the San Diego Mesa.

Three specimens of the type lot collected by Henry Hemphill bear the numbers 525, 525a, 525b in the series of type specimens in the California Academy of Sciences. The largest of these is 97.6 mm long, 83 mm high, convexity (both valves together), 18.3 mm. A large left valve from Loc. 1401 (CAS), south slope of Mount Soledad is 100 mm long and 85 mm high.

Pecten stearnsii is an extinct species and, as mentioned by Dall and by Arnold, it is the precursor of *P. diegensis* Dall (269), a Recent species which occurs at

the present time in waters off San Diego.

Pecten stearnsii differs from the Recent species in the greater number of ribs, 23 to 26 on the right valve and about 24 on the left valve in comparison to 19-21 on the right valve of *P. diegensis* and 20-21 on the left one. Furthermore, the hinge line of *P. stearnsii* is shorter, the ribs are usually more deeply medially sulcated and the interspaces between the ribs are narrower than those of *P. diegensis*. Woodring, Bramlette, and Kew (1946, p. 80) called attention to the fact that near the margin of the interior of the right valve of *Pecten diegensis* a flange occurs along each edge of the projection corresponding to the interspace on the exterior. Similar flanges appear to be lacking or but slightly developed near the anterior and posterior ends of the right valve of *P. stearnsii*.

The two forms are very similar but in our opinion the differences are sufficient to justify recognition of each as a separate species. Grant and Gale (1931, p. 223) and Woodring, Bramlette, and Kew (1946, p. 80) considered *Pecten diegensis* to be a subspecies of *P. stearnsii*. *Pecten lunaris* Berry (270), a Recent species described from the Gulf of California, is a member of this group.

Pecten sericeus Hinds (271), a Recent species originally described from Panama, differs from *P. stearnsii* and *P. diegensis* in that the ribs, especially toward the ventral margin on adult right valves, often develop a low, median, tricarinate ridge.

Three fossil forms of Pliocene age in the Gulf of California region are closely allied to *P. stearnsii*.

Pecten carrizoensis Arnold (272) described from strata of Pliocene age in eastern San Diego County, has fewer (18 or 19 on right, 17 on the left valve) and less prominent ribs, which are separated by narrower interspaces than those on *P. stearnsii*.

Pecten bcali Hertlein (273) described from strata of Pliocene age on the east coast of Lower California, differs from *P. stearnsii* in that the ears of the right valve bear radial riblets and in that a fine radial riblet occurs in each interspace between the radial ribs on the left valve. *Pecten ochlockoneensis violac* Tucker (274) from beds of Miocene age in Florida is an allied species.

Pecten bösei Hanna and Hertlein (275), described from beds of Pliocene age on the east coast of Lower California, differs from *P. stearnsii* in possessing lower, nonsulcated, often almost smooth ribs. Specimens from Pliocene beds in the Gulf of California region referred to *P. stearnsii* by Hanna and Hertlein (1927) are not typical of that species, but are more nearly allied to *P. bösci*. Vokes (276) cited a species under the name of "*Patinopecten* cf. *stearnsii*" from the Gloria Formation of Pliocene age on the east coast of Lower California.

Pecten soror Gabb (277), described from beds of Miocene age in Santo Domingo and *Pecten soror codercota* Harris (278), described from late Tertiary strata in Venezuela, apparently are members of the *P. stearnsii* group.

Pecten stearnsii occurs rather commonly in beds of middle and late Pliocene age along the coastal region of southern California from Ventura County to San Diego and along the west coast of northern Lower California, at Cedros Island, Turtle Bay, and elsewhere on the peninsula and at Maria Madre Island, Tres Maris Islands. We have not seen typical specimens of *P. stearnsii* from strata other than of Pliocene age. However, the specimens

illustrated by Woodring, Bramlette, and Kew (1946, pl. 32, figs. 14, 15), from unit 1 of the Timms Point silt at San Pedro, appear to be referable to this species. Those authors considered this silt to be of Pleistocene age but many authors earlier considered it to be of late Pliocene age.

Pecten stearnsii is allied to *P. diegensis*. The former species may have occupied habitats similar to *P. diegensis*, which lives in west American waters from Cordell Bank, off central California, to Gorda Bank, off Cape San Lucas, Lower California, Mexico. The bathymetric range of *P. diegensis* given by Grau is 9 to 366 meters (5 to 200 fathoms). According to Fitch (279) "This scallop usually swims a few feet off the bottom in rocky areas from five to seventy-five fathoms beneath the surface." It occurs in beds of Pleistocene age in southern California.

SUBGENUS *OPPENHEIMOPECTEN* VON TEPPNER

Oppenheimopecten von Teppner, Fossilium Catalogus 1: Animalia Pars 15, Anisomyaria II, p. 254, 1922. — von Teppner, quoted in Roger, Mém. Soc. Géol. France, Nouv. Sér., Tome 17, Fasc. 2-4, Feuilles 7-43, Mém. No. 40 (suite et fin du Mém. de Paléo., No. 26 et du Mém. N. S., No. 10), p. 242, 1939. Type *P. subbenedictus* Fontannes. — Grau, Allan Hancock Pac. Exped., Vol. 23, p. 148, 1959. Type *Pecten subbenedictus* Fontannes.

Convexopecten Tucker-Rowland, Jour. Conch., Vol. 21, No. 3, p. 82, September 22, 1938. "with genotype *Pecten* (*Convexopecten*) *joslingi* (Smith), Quart. Jour. London Geol. Soc., 3:419, pl. XVI, figs. 10-12, 1847."

Type species (by original designation, von Teppner, 1922, p. 254). — "Typus: *Pecten* (*Oppenheimopecten*) *subbenedictus* Fontannes." [*Pecten subbenedictus* Fontannes, Etudes stratigraphiques et paléontologiques pour servir à l'histoire de la période tertiaire dans le Bassin du Rhône: III, le Bassin de Visan (Vaucluse), (Lyon), p. 83, pl. 2, fig. 1, 1878. — Depéret and Roman, Mém. Soc. Géol. France, Paléo., Tome 10, Fasc. 1, Mém. No. 26, p. 39, pl. 5, figs. 1, 1a, 2, 1902. Southern France, Burdigalian, Miocene.]

Range. — Early Miocene (Burdigalian) to Recent. Recent in Indo-Pacific, Australia, Japan, Hawaii, and in the eastern Pacific, in shallow tropical and subtropical waters.

Original description (translation). — Inequivalve, right valve strongly convex (umbo strongly incurved) with rounded ribs, broader than the interspaces. Ears large, unequal. Ribs of left valve flat and broad, narrower than the interspaces. Concentric sculpture of right valve very weak, the left distinct. (Translation by Grau of von Teppner's original description in Roger.)

Remarks. — The most characteristic feature of this subgenus is the very highly convex right valve with incurved umbo overhanging the left valve. The left valve may be nearly flat or shallowly to moderately concave.

In the Mediterranean region, *Oppenheimopecten* is represented by perhaps fifteen or more species and subspecies described from strata of Miocene and Pliocene age. In the eastern Pacific this subgenus is represented by eight species, *P. juanensis* Grant and Eaton in the late Miocene, *P. coalingensis* Arnold in Anderson, *P. hartmanni* Hertlein, and *P. heimi* Hertlein in the Pliocene, and the

Recent species, *P. galapagensis* Grau, *P. hancocki* Grau, *P. perulus* Olsson and *P. vogdesi* Arnold. In the Indo-Pacific region, *Oppenheimiopecten* is represented from Pliocene to Recent, including Recent species such as *P. erythraeensis* Sowerby, *P. fumatus* Reeve, *P. albus* Tate and *P. excavatus* Anton.

Fleming (280) gave an excellent discussion of the members of the *Pecten benedictus* group (referable to *Oppenheimiopecten*), in New Zealand and Australia.

Pecten (Oppenheimiopecten) vogdesi Arnold
Plate 29, Figures 1, 3, 5, 6

Pecten dentatus Sowerby, Proc. Zool. Soc. London for 1835, p. 109, October 9, 1835. "Hab ad Sanctam Elenam." "Found among sand and stones in twelve fathoms." — Sowerby, Thes. Conch., Vol. 1, p. 49, pl. 15, figs. 105, 106, 1842.

Not *Pecten dentatus* J. Sowerby, 1829. Fossil in Great Britain.

Pecten excavatus Valenciennes, Zool. Voy. Venus, pl. 19, figs. 1, 1a, 1b, 1c, 1846. [No description or locality.] Not *Pecten excavatus* Anton, 1839. China.

Janira dentata Sowerby, Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 28, 1878. "Well" at San Diego. — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 244, 1888. [Quaternary records only according to Arnold, 1906.] — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 86, August, 1889. Dall's record (1878) cited. — Orcutt, quoted by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 60, 1919. Dall's record (1878) cited.

Pecten (Pecten) dentatus Sowerby, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 104, pl. 12, figs. 1, 1a, 1903. Pleistocene and Recent. P. 105, "Pliocene. — San Diego well (Cooper) — (Probably *P. hemphilli*)."

Pecten (Pecten) vogdesi Arnold, U. S. G. S., Prof. Paper 47, p. 100, pl. 33, figs. 1, 1a, pl. 34, fig. 1, 1906. "The type of this species (a right valve) is from the upper San Pedro formation at San Pedro," California, Pleistocene. Also cited from "Pliocene (?). San Diego (Hemphill); Cholas Valley near San Diego (Stearns)." — Arnold in Eldridge, U. S. G. S., Bull. 309, p. 242, pl. 35, fig. 5 (Pleistocene, Ventura County), 1907. "Also occurs in supposed Pliocene near San Diego." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 158, pl. 20, figs. 4, 4a, 4b, 1961. Range: Magdalena Bay, Lower California, Gulf of California to Panama.

Pecten (Euvola) cataractes Dall, Nautilus, Vol. 27, no. 11, p. 121, March, 1914. "For this common species of the Gulf of California I propose the name of *Pecten (Euvola) cataractes*."

Pecten (Janira) vogdesi Arnold, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 228, pl. 3, figs. 3a and 3b (Recent, Gulf of California), 1931. "Pliocene: 31st Street and Logan Avenue, San Diego (Sternberg Collection, 1924, specimen at Stanford University)." Earlier records cited.

Pecten (Oppenheimiopecten) vogdesi Arnold, Grau, Allan Hancock Pac. Exped., Vol. 23, p. 149, pl. 55, 1959. Pliocene to Recent. Recent, Punta Eugenia, Lower California, to the Gulf of California and South to Paíta, Peru.

Type specimen. — No. 4 Stanford University, Department of Geology. Type Collection.

Type locality. — "from the upper San Pedro formation at San Pedro", Los Angeles County, California; Pleistocene.

Range. — Middle Pliocene to Recent. Recent from Punta Eugenia, western Lower California, Mexico, to the head of the Gulf of California and south to Panama, in 4 to 219 meters (2 to 120 fathoms) (Grau). "Usually found in sand, sandy mud, or mud bottom, associated with coral, coralline or sponge." (Grau.)

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 1137. L.A.M. 320, 320A, P.87: No. 8325. S.U. Same locality as C.A.S. 1137.

Original description. — Shell similar to *P. excavatus*, except averaging larger and with the following differences: Right valve, somewhat less convex, has 19 or 20 broader, flatter ribs, which are separated by relatively broader interspaces that occasionally show faint intercalary riblets or faint longitudinal striations. Left valve with fewer ribs than *P. excavatus*, and having no intercalary riblets, or faint ones, which become obsolete near the periphery of the disk; ears slightly less concave than in *P. excavatus*. (Arnold.)

Dimensions. — Alt. 69 mm; hinge line to ventral margin (right valve) 67 mm; long. 73 mm; hinge line 35 mm; diameter 24 mm; umbonal angle (left valve) 98°. (Arnold.)

Remarks. — This species was recorded from the San Diego well by Dall and by Cooper. Arnold (1906) did not refer to Dall's record (1878) of this species from the San Diego well, but he did mention that Cooper's record (presumably based upon that of Dall) of "*Janira dentata*" was in part referable to *P. stearnsii*. Whether or not Dall's record should be referred to *P. stearnsii* is unknown to us. Arnold mentioned that specimens of this species were collected by Stearns from beds of Pliocene age in Las Chollas Valley and that others were collected by Hemphill in San Diego in strata of probable Pliocene age.

One right valve and three left valves in the collections of the California Academy of Sciences, were collected by Charles Sternberg from 31st Street near 32nd Street and Logan Avenue, San Diego. One right and one left valve from the same locality are in the collections of Stanford University. One right and two left valves from 32nd and Woolman streets, San Diego, are in the collections of the Los Angeles County Museum. One of the left valves is 110 mm long and 90.5 mm high. Additional specimens were collected by Kanakoff at Locs. 320 and 320A, and at 835, 32nd Street, San Diego.

These specimens occur in fine, hard, gray, cemented sandstone. Some of them are of a reddish-brown color. The largest, a left valve from Loc. 320A, is 111.5 mm long and 86.9 mm high. According to Kanakoff, these specimens, along with specimens of *Pecten circularis* and other species embedded in hard matrix, occur in beds definitely referable to the San Diego Formation. Above this bed is a layer about a foot thick containing abundant *Chione catiforniensis* and *Lucina nuttalli*. The preservation of the *Chione* and the lithology of the reddish-brown bed are clearly not referable to the San Diego Formation.

The observable shell characters of the Pliocene *P. vogdesi* do not differ from Recent specimens. On some left valves the interspaces lack a radial riblet but on others it

is present. This feature varies in both fossil and Recent specimens. The hinge of juvenile specimens has but one pair of crura but adults have two pairs.

Pecten (Pecten) heimi Hertlein (281) described from strata of Pliocene age in Lower California is a similar species but that it is identical with *P. vogdesi*, as believed by Grant and Gale, is open to question. The ears of the type specimen are weakly sculptured and the ears of the left valve are smooth, whereas the ears of Recent *P. vogdesi* are ornamented with well defined riblets.

Pecten (Pecten) juanensis Grant and Stephenson (282), described from beds of late Miocene age in San Luis Obispo County, California, has smooth ears and the apical angle is about 90° rather than 95° to 100° in *P. vogdesi*. Grant and Stephenson suggested that *P. juanensis* might be the precursor of *P. coalingaensis* Arnold in Anderson (283), and *P. vogdesi*.

Pecten (Oppenheimopecten) hancocki Grau (284), a Recent species from Cocos Island, has only 16 to 17 ribs and the right valve is much less convex than that of *P. vogdesi* and it differs in other details.

In general appearance *P. vogdesi* bears a general resemblance to some members of the *P. benedictus* group and especially the *P. aduncus* group (285) in the Miocene of the Mediterranean region but there are differences in the shape of the ribs and in other details.

Except for its occurrence in the San Diego Formation, *Pecten vogdesi* has been reported from southern California only in beds of Pleistocene age. It is known to occur in beds of Pliocene and of Pleistocene age in the Gulf of California region as well as in Pliocene strata at Maria Cleofa Island, Tres Maris Islands, and in beds of Pleistocene age at Magdalena Bay, Lower California. It also has been reported from beds of Pleistocene age along the coast of Panama and Ecuador. This interesting species has been taken at many localities in the Gulf of California.

The range of Recent *P. (O.) vogdesi* usually cited in the literature, is from the Gulf of California to Paita, Peru. Olsson recently mentioned that this species does not occur south of Panama and that he observed no specimens from south of Mexico. He described a species from Santa Elena, Ecuador, under the name of *Pecten (Pecten) perulus* (286), the range of which is given as Panama to Lobitos, Peru. This Peruvian species was described as differing from *P. (O.) vogdesi* in its smaller size and thinner texture as well as "by its lower convexity of the right valve, its lower umbone which does not rise above the hinge margin and by its sulcated or mesially grooved ribs. The left valve differs by its wider, more flaring submargins and especially by its narrower ribs, and much wider interspaces, each carrying an intercalary riblet." Specimens of *P. perulus* in the collections of the California Academy of Sciences collected by Dr. Robert Hoffstetter (287) (who called attention to differences in the shell characters of this southern species and those of *P. vogdesi*) from Santa Elena, Ecuador, are purplish in color and smaller than *P. (O.) vogdesi*. The largest, a left valve, is 39.5 mm long. Other similar specimens were collected in Peru by Dr. Don L. Frizzell. The ribs on the right valves are shallowly sulcated near the ventral margin.

SUBGENUS PATINOPECTEN DALL

Patinopecten Dall, Trans. Wagner Free Inst. Sci., Vol. 3,

Pt. 4, p. 695, April, 1898. "Type *P. caurinus* Gld." — Arnold, U. S. G. S., Prof. Paper 47, p. 48, 1906. "Type *P. caurinus* Gould." — Grau, Allan Hancock Pac. Exped., Vol. 23, p. 145, 1959. Type species *Pecten caurinus* Gould. — MacNeil, U. S. G. S., Prof. Paper 354-J, p. 225, 1961. "Type: *Pecten caurinus* Gould." — MacNeil, U. S. G. S., Prof. Paper 553, p. 40, 1967.

Type species (by original designation). — *Pecten caurinus* Gould [Proc. Boston Soc. Nat. Hist., Vol. 3, p. 345, December, 1850. "Hab. Port Townsend, Admiralty Inlet, Oregon." [Washington.] — Gould, U. S. Explor. Exped. (Wilkes), Vol. 12, p. 458, 1852; atlas pl. 42, figs. 569, 569a, 569b, 1856. Original locality cited. — Arnold, 1906, p. 101, pl. 38, figs. 1, 1a, 1b; pl. 39, figs. 1, 2. Pliocene to Recent. — Grau, 1959, p. 145, pl. 54, 1959. Range: Channel Inlet, Orca Inlet, Cordova, Alaska, to Point Reyes, California].

Range. — ?Late Oligocene; early Miocene to Recent. Recent from central California to Japan. In about 18 to 91 meters (10 to 50 fathoms).

Description. — Shell large, nearly equilateral, rather flat, right valve slightly more convex than the left; ribs on the right valve flat and sometimes dichotomous, those on the left valve smaller and rounded; radial striae absent or inconspicuous; ears subequal, the right anterior one with a byssal notch; hinge nearly smooth, auricular denticles often present. (Adapted in part from Dall.)

Remarks. — Two specimens of a fossil *Pecten* from beds considered to be of middle Oligocene age in western Oregon were referred to *Patinopecten* by Schenck (288). These specimens are incomplete and poorly preserved and we are not certain whether or not they are referable to that taxonomic unit. MacNeil stated that the earliest American species of *Patinopecten* is known from beds of late Oligocene or early Miocene age in Alaska. This subgenus is represented in beds of middle Miocene age in Washington, Oregon, and California by *Pecten (Patinopecten) propatulus* Conrad and two varieties of that species have been described from central California. *Pecten caurinus* Gould and *P. oregonensis* Howe occur in beds of Pliocene age and the former also occurs in the Pleistocene and Recent. Several west American species formerly placed in *Patinopecten* were later referred to *Lituyapecten* MacNeil.

In Japan, Akiyama (289) referred 33 species to *Patinopecten* which he considered to be a genus ranging from late Oligocene to Recent, and he placed five others in a new subgenus *Masudapecten* (290). The latter was described as "allied to *Patinopecten* (s. str.), but can be distinguished from the right valve with less elevated radials and with conspicuous ctenolium and the left valve with less conspicuous threads."

Most of the Cenozoic pectens of Japan, formerly assigned to *Patinopecten*, were recently placed by Masuda (291) in four genera included in a new subfamily Fortipectininae. The species were distributed among *Masudapecten* Akiyama (type, *Masudapecten masudai* Akiyama), *Kotorapecten* Masuda (type, *Pecten kagamianus* Yokoyama), *Mizuhopecten* Masuda (type, *Pecten yessoensis* Jay) and *Nipponopecten* Masuda (type, *Pecten akihoensis* Matsumoto).

The taxonomic value of some of these genera may be open to question, but we withhold judgment of them because we have not studied large collections of Cenozoic

pectens from Japan.

Most workers have considered *Pecten yessoensis* Jay, the type of *Mizuhopecten* (Masuda, 1963, p. 151), to be closely allied to *Pecten caurinus* the type of *Patinopecten*. However, *Mizuhopecten* was differentiated from *Patinopecten* chiefly "by its having no auricular crurae with distal denticle, rounded, broad radial ribs and large auricles with wide and shallow byssal notch". A consideration of these shell characters led Masuda to place *Mizuhopecten* in the subfamily Fortipectininae.

Blanckenhornia von Teppner (292) has as type species *Pecten oweni* Arnold (not of De Gregorio, 1884), now known as *Pecten lohri* Hertlein, an early Pliocene species in California, with dichotomous ribs. This species and its descendant, *Pecten healey*, were apparently inhabitants of comparatively warm water. These two later Tertiary species with deeply medially sulcated ribs could be segregated under the separate subgenus *Blanckenhornia*. However, the degree of development of the medial sulcation of the ribs varies with species and may be of specific rather than of generic value. For this reason we have placed *Pecten healey*, which occurs in the San Diego Formation, in *Patinopecten*.

Jaworski (293) suggested a possible relationship of *Pecten oweni* Arnold (*P. lohri* Hertlein) with the early Jurassic *Pecten bodenbenderi* Behrendsen stock. Behrendsen's species is now assigned to the genus *Weyla* J. Böhm (type, *P. alatus* von Buch) and the suggested relationship with *P. lohri* is not evident from our research. The cardinal laminae on the hinge of *W. alata* are well developed and transversely grooved (see Jaworski, fig. 7).

Fortipecten Yabe and Hatai (294) includes a group of Pliocene species occurring in the north Pacific from Japan to Alaska. Typical forms of this group have thick shells and decidedly convex right valves with the beak overhanging that of the left valve.

Vertipecten Grant and Gale, was based upon *Pecten nevadanus* Conrad (*P. bowersi* Arnold), a Miocene species. This group of large chlamyds is quite distinct from *Patinopecten*, differing especially in that the left valve is more convex than the right one and is ornamented with large, rounded, scaly, irregular ribs of which every third or fourth usually is higher than the others.

Pecten (Patinopecten) healey Arnold

Plate 31, Figures 1, 4, 6, 7; Plate 33, Figure 9;

Plate 36, Figures 8, 9; Text Figure 9

Pecten expansus Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 14, 1878. Later Tertiary of San Diego. — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. "well-digging in stratum B²", San Diego; p. 29, "(stratum C)" "about ten miles northward from San Diego, on the seacoast of California". — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 87, 1889. Dall's record (1878) cited. — Cooper, Calif. State Min. Bur., Bull. No. 4, p. 31, 1894. "Pl. — San Diego." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 63, 1903. "Pacific Beach." Pliocene. — Orcutt, quoted by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 60, 1919. Dall's record (1878) cited.

Not *Pecten expansus* Smith, Quart. Jour. Geol. Soc. London, Vol. 3, pp. 413, 419, pl. 18, fig. 21, 1847.

Pecten (Patinopecten) expansus Dall, Dall, Trans. Wagner

Free Inst. Sci., Vol. 3, Pt. 4, p. 706, pl. 26, fig. 1, April, 1898. "Pliocene of Pacific Beach (lower horizon), near San Diego, California." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 108, 1903. "Pliocene. — Pacific Beach, San Diego (Hemphill; Dall; Hamlin; Arnold)." — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. 53, Pt. 1, p. 487, 1905. "Pliocene. Near San Diego, California."

Pecten (Patinopecten) healey Arnold, U. S. G. S., Prof. Paper 47, pp. 28 (as *Pecten healey*), 103, pl. 36, figs. 1, 1a; pl. 37, figs. 1, 1a, 2, 1906. "San Diego formation (Pliocene), Pacific Beach, San Diego County, Cal."; "Tiajuana, Mexico (A. W. Greeley)"; also "Purisima formation (lower Pliocene), near San Gregorio, San Mateo County, Cal." — Arnold, in Eldridge, U. S. G. S., Bull. 309, p. 240, pl. 34, fig. 1, 1907. Type. "San Diego formation (Pliocene), San Diego County." — Arnold and Anderson, U. S. G. S., Bull. 322, p. 154, pl. 26, figs. 1, 2, 1907. "San Diego formation (Pliocene), Pacific Beach, San Diego County, Cal." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 196, pl. 6, figs. 2a, 2b, 1931. Pacific Beach. "Middle Pliocene." Earlier records cited of Dall and others from San Diego. — Hanna and Hertlein, Calif. State Div. Mines, Bull. 118, Pt. 2, p. 176, fig. 3, 1941. "Pacific Beach, San Diego, California. San Diego formation, middle Pliocene." — Hertlein and Grant, Calif. Jour. Mines Geol., Rept. 35 State Mineral., p. 69, 1939. Gray sandstone overlying the basal conglomerate "about 1,200 feet south of the west end of Law Street." Pacific Beach, Pliocene. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 59, 1944. "bottom (60 feet) of David Smallcomb's well just north of the Mexican Boundary, in the bottom of Matadero Canyon, four-tenths of a mile west of the United States-Mexico Boundary monument No. 256," Pliocene. — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 87, 1944. Earlier records cited. — Hertlein and Grant, Calif. State Div. Mines, Bull. 170, Chap. 2, p. 60, 1954. "San Diego formation," Pliocene. — Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 46, pl. 21, figs. a, b, 1968. Pacific Beach, Pliocene.

P[ecten]. californicus Cossmann and Peyrot, Actes Soc. Linn. de Bordeaux, Tom. 68 (Conch. Néog. de l'Aquitaine, Tom. 2, Livre. 2 et Suppl.), p. 292, August 1, 1914. New name for *Pecten expansus* Dall, 1878. "fossile du Pliocène de Californie."

Not *Pecten californicus* Gabb, 1864. California, Cretaceous.

Pecten healey Arnold, McLaughlin and Waring, Map Folio accompanying Bull. 69, inside of back cover, species 42, pl. 1, fig. 42, 1914 (1915). "Etchegoin (San Diego) formation of Pacific Beach, San Diego Co., California." — J. P. Smith, Calif. State Min. Bureau, Bull. No. 72, p. 38, 1916. "San Diego and lower Fernando formations of the coastal region of southern California." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, pp. 150, 151, 1919. "San Diego." Pliocene. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, pp. 83, 84, 85, 1929. "San Diego Pliocene." — Hertlein and Grant, Calif. State Div., Mines, Calif. Journ. Min. Geol., Rept. 35 of State Mineral., pp. 69, 70, 71, 1939. Dall's record (1874) cited. Also "South slope of Soledad Mountain"; "David Small-

comb's well just north of the Mexican boundary and west of Tijuana, Mexico." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, pp. 56, 57, 59, 1944. "India Street, particularly at the corner of Upas Street;" "thirty to forty feet above the base of the section" at Pacific Beach; also "south sloping spurs of Mount Soledad"; "near the Mexican Boundary about three-quarters of a mile from the sea," Pliocene. — Milow and Ennis, 57th Ann. Mtg. Cordilleran Sec. Geol. Soc. Amer., Field Trip Guidebook San Diego Co. — 1961, p. 28, 1961. "San Diego Formation."

Patinopecten healey Arnold, Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, 1941. "Strata at Pacific Beach," "San Diego," Pliocene. Also see Stewart, p. 92, "Pliocene at San Diego." — Woodring, U. S. G. S., Prof. Paper 222, p. 104, 1950. "Pacific Beach and inland," Pliocene. — Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. "San Diego formation." Also Niguel Formation and others. — Masuda, Trans. Proc. Palaeont. Soc. Japan, New Ser., No. 52, pp. 147 (in text), 152, pl. 23, figs. 2a, 2b, 2c, 1963. "Loc. Rose Canyon, La Jolla Quadrl., San Diego, California, U. S. A. Pliocene." — Glibert and Van de Poel, Mém. Inst. Roy. Sci. Nat. Belgique, Deuxième Sér., Fasc. 78, p. 22, 1965 (as *Patinopecten* (s. s.) *healey*). Pacific Beach, San Diego, California, Pliocene.

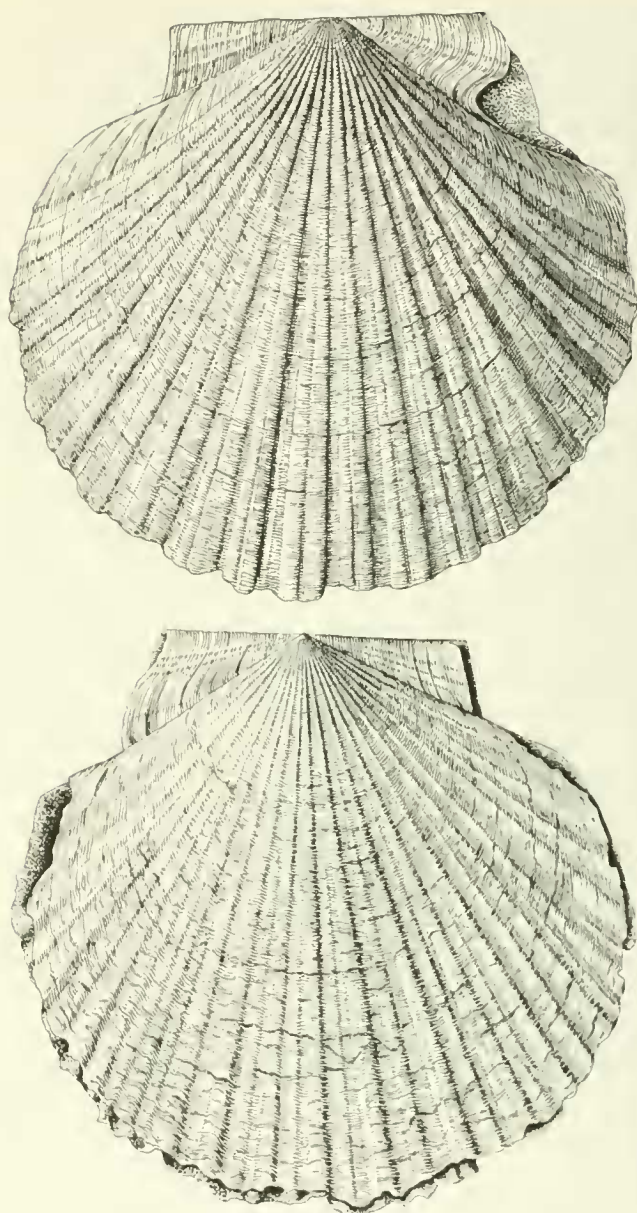
Type specimen. — No. 148012, United States National Museum.

Type locality. — "San Diego formation (Pliocene), San Diego County, Cal."

Range. — Middle Pliocene, from Ferndale quad., California (Ogle), to Cedros Island and Bahía Tortolo (Turtle Bay), Lower California, Mexico.

Occurrence in San Diego Fm. — C.A.S. 104, 105, 547, 957, 1130, 1135, 1138, 1177, 1178, 1179, 1181, 1182, 1183, 1186, 1199, 1399, 1400, 1401, 1404, 1413, 1414, 1418, 1419, 28158, 28453, 28454. L.A.M. 107, 122, 127, 305, 305A, 309, 318, 1132, A1323. S.D. 5, 10, 17, 21, 24, 27, 36, 37, 80, 88, 150, 331, 365, 402, 403, 404, 408, 417, 6304. U.C. A-8333. U.C.L.A. 294, 295, 298, 299, 300, 302, 309, 310, 312, 1384, 1385, 2359, 2420.

Original description. — Shell averaging about 130 millimeters in altitude, length about equal to height, inequivalve (the right slightly more ventricose than the left), equilateral, and with smooth margins; base evenly rounded; sides only slightly concave above. Right valve somewhat ventricose, and ornamented by 18 to 21 strong, squarish, sub-equal primary ribs, which become more or less dichotomous, and sometimes trichotomous, after 30 or 40 millimeters in length; medial sulcus of rib more or less deep, in some cases being as deep as the interspaces near the ends, thus completely dividing the primary rib; interspaces subequal, much narrower than the ribs, quite deeply channeled, and often ornamented by a small, rounded intercalary riblet; whole surface crossed by numerous fine lines of growth; hinge line less than one-half length of disk; anterior ear only slightly longer than left, arcuate in front, and ornamented by several obsolete radial ridges and numerous sharp incremental lines; byssal notch quite prominent; posterior ear slightly obliquely truncated, and ornamented by sharp incremental lines and sometimes by obsolete radiating ridges. Left valve



Text Fig. 9. *Pecten* (*Patinopecten*) *healey* Arnold. Hypotype (Cat. No. 1950, University of California at Los Angeles), from Pacific Beach, San Diego; Pliocene. Length 130.8 mm. A. Right valve. B. Left valve. (Drawn by E. H. Quayle.)

much compressed; ribs narrow and rounded, more or less sharply toward the top (there being in some cases a narrow, slightly raised line along the top); interspaces wide, and each ornamented by a more or less prominent, rounded, intercalary riblet; whole surface striated concentrically by fine, sharp, wavy lines; ears obliquely truncated and sculptured similarly to those of the right valve. (Arnold.)

Dimensions. — Alt. 112 mm; long. 112 mm; hinge line, 50 mm; diameter 18 mm. (Arnold.)

Remarks. — This large, rather flat pecten is easily recognized by its flat-topped, medially sulcated radial ribs on the right valve and the rounded ribs with an intercalary in each interspace on the left valve. *Pecten healeyi* occurs at nearly every locality where fossils are found in the San Diego Formation in and near San Diego, California.

Juvenile specimens are smooth in the early stage but usually radial undulations of the anterior margin begin to form after the shell has attained a height of 3 to 5 mm. Occasionally specimens remain smooth up to a height of 23 mm. The ribs on the right valve, especially those toward the anterior and posterior margins, begin to develop a slight medial sulcus after the shell has attained a height of 10 mm, but such sulcations on the medial ribs are well developed only after a height of 30 to 40 mm has been attained. Occasionally the ribs on large specimens may bear two sulcations which thus divide the major ribs into three small riblets, but such forms, so far as known, have no taxonomic significance. One such right valve with a strong intercalary in each interspace from Pacific Beach in the collections of the San Diego Society of Natural History, is 165 mm high. The largest specimen of *Pecten healeyi* seen by us is one collected by G. P. Kanakoff from Loc. 107 (LAM), end of Arroyo Drive, San Diego, which is 222 mm long and 195 mm high. The hinge (incomplete) of a portion of a left valve in the same institution collected by Roy L. Moodie at Pacific Beach, is 99 mm long. The shell on lateral areas of the umbonal portion is 6 mm thick.

A low, narrow ridge is present on each side of the ligamental pit. The umbonal portion of the interior of many valves is covered with a layer of calcareous material, the weathered surface of which reveals a network of many fine, irregularly arranged plates or cells.

Pecten healeyi appears to be a descendent of *Pecten lohri* Hertlein (295) as mentioned by Arnold. He pointed out that some forms occurring in the Purisima Formation in San Mateo Co. (296), California, appear to be intermediate between *Pecten healeyi* and *Pecten lohri* in their respective lowest and highest stratigraphic ranges.

The stratigraphic ranges of these two species have been well defined by Woodring in the Santa Maria district, Santa Barbara Co., California. In that district *Pecten lohri* occurs questionably in diatomaceous strata of uncertain age and in the overlying Todos Santos Claystone and in the Tinaquaic Sandstone, the latter two of early Pliocene age. Overlying these are the Foxen Mudstone and Careaga Sandstone in which *Pecten healeyi* occurs. These are of approximately middle Pliocene age.

Compared to *Pecten healeyi*, the shell of *Pecten lohri* is smaller, more convex, has fewer (14 to 16) and coarser ribs on the right valve and it has a longer hinge line. The medial sulcations on the ribs begin nearer the dorsal margin than they do on *P. healeyi*, and the intercalary ribs are coarser.

Pecten healeyi and *P. lohri* are Pliocene members of a group which includes *Pecten propatulus* Conrad (297), described from mid-Miocene strata at Astoria, Oregon, and the only slightly different varieties described as *P. haywardensis* Lutz (298) and *P. haywardensis calaverasensis* Hall (299) from mid-Miocene strata in central California.

Pecten healeyi is quite distinct from *P. propatulus* and differs in the more numerous and more deeply sulcated ribs on the right valve, finer ribs on the left valve

and smaller byssal fasciole beneath the right anterior ear. *Pecten oregonensis* Howe (300), described from Pliocene beds at Coos Bay, Oregon, is said to differ from *P. propatulus* in the higher ribs, wider umbonal angle, and in other details.

Pecten tryblum Yokoyama (301) from the late Miocene and Pliocene of Japan bears a resemblance to *P. healeyi* but is longer in proportion to the height, the ribs on the right valve appear to be proportionally narrower and the hinge line is longer.

Pecten yamasakii Yokoyama (302) was placed questionably in the synonymy of *Pecten healeyi* by Grant and Gale, and Kuroda (303) placed it as a subspecies of *P. healeyi*. The Japanese species is said to possess 19 to 22 tripartite ribs on the medial portion and bipartite ribs on the anterior and posterior portions of the right valve. A subspecies, *Pecten yamasakii ninohensis* Masuda (304) is another member of the Japanese group. These oriental forms differ sufficiently from the west American fossils to constitute distinct species. They were placed in the genus *Kotorapekten* by Masuda in 1963.

Pecten duplex Cooke (305) described from beds of mid-Tertiary age on the island of Antigua in the Caribbean Sea, was compared by its author with *Pecten healeyi*. The Caribbean form has medially sulcated ribs on the right valve but it is said to be smaller and the ribs on the left valve are square-topped and bear a shallow medial groove. This latter feature is reminiscent of *Pecten yakatagensis* Clark (306) which was described from strata of Pliocene age in southeastern Alaska but the two are not closely related. Olsson and Richards assigned the Antigua fossil to *Flabellipecten*. The form illustrated by Manning and Ogle under the name of "*Pecten oregonensis* Howe var." (307) from Boulder Creek near Ferndale, California, also has square-topped medially grooved ribs on the left valve. It was described later by MacNeil as *Patinopekten (Lityapekten) falorensis* (308).

Pecten healeyi is an index fossil of the San Diego horizon, middle Pliocene, of California and northern Lower California. It has been reported from many localities from Ferndale, northern California, to Cedros Island and Bahía Tórtolo (Turtle Bay), Lower California, Mexico. Also from Santa Cruz Island, California.

This species lived in warm water unlike its northern relative *Pecten caurinus* Gould which followed it in stratigraphically later Pliocene and Pleistocene beds in California.

[*Pecten* (?*Patinopekten*) *merriami* Arnold]

Pecten (*Pecten*) *merriami* Arnold, U. S. G. S., Prof. Paper 47, p. 99, pl. 30, figs. 1, 1a, 2, 1906.

[*Pecten*]. *merriami* Arnold, J. P. Smith, Calif. State Min. Bureau, Bull. No. 72, p. 38, 1916. "San Diego and lower Fernando formations of the coastal region of southern California." Pliocene.

Type specimen. — Number 12086, University of California, Museum of Paleontology.

Type locality. — "from light-colored shale underlying the conglomerate on San Felician Creek, near Piru, Ventura County," California. "Pliocene (lower)."

Range. — Probably middle or late Pliocene.

Remarks. — The only record of occurrence of *Pecten merriami* in the San Diego Formation is the equivocal one

of J. P. Smith. We have not seen any specimens from the Pliocene beds at San Diego which could be referred to this species.

We have examined a cast of the holotype, No. 6100 (Calif. Acad. Sci. Dept. Geol. Type Coll.), and we can add but little to Arnold's discussion of this species. The hinge on the type specimen is lacking as is the shell on most of the umbonal area. A few ribs on the lateral areas are slightly but definitely medially sulcated. The taxonomic status of this species is uncertain.

SUBGENUS *LITUYAPECTEN* MACNEIL

Lituyapecten MacNeil, U. S. G. S., Prof. Paper 354-J, p. 227, 1961.

Type species (by original designation). — *Patinopecten* (*Lituyapecten*) *lituyaensis* MacNeil [1961, p. 231, pl. 39, figs. 1, 3; pl. 40, figs. 1-5; pl. 41, fig. 1; pl. 42, figs. 1, 2, 4; pl. 43, figs. 1-4. "Type locality. — Upper mudstone unit of unnamed upper Tertiary formation, about 300 to 340 feet above the base of the upper mudstone unit, southwest of Cenotaph Island, Lituya Bay, Alaska, USGS M270". Pliocene].

Range. — Late Oligocene (Poul Creek Formation) or early Miocene, to middle Pliocene, Alaska; Pliocene of Washington, Oregon, California, and northern Lower California, Mexico.

Description. — "The new subgeneric name, *Lituyapecten*, is here proposed to include the species of *Patinopecten* having one to several rows of frill-like flanges on the ribs of the left valve" (MacNeil, 1961, p. 228).

Remarks. — This group of scallops is generally referred to *Patinopecten* in earlier works. In support of possible relationship with *Patinopecten*, MacNeil reported the presence of small frill-like flanges close to the beak the ribs of some left valves of *Pecten* (*Patinopecten*) *propatulus*. The same author pointed out the difficulty of identification based only on right valves which may be similar in some members of *Lituyapecten* though the left valves may be quite dissimilar.

The ribs on the left valves of several species in this group are high, narrow and flat-topped, those on the right valve, flat-topped or rounded and often undercut on the sides. In addition to the frill-like flanges on the ribs, concentric microsculpture is present on the valves. MacNeil mentioned that the fine imbricating microstructure present on many specimens of *Patinopecten* and *Swiftopecten* was not observed by him on any specimens of *Lituyapecten*.

Seven species from the medial Tertiary of western North America were assigned to *Lituyapecten* by MacNeil. One of these is present in the San Diego Formation.

Pecten (*Lituyapecten*) *dilleri* Dall Plate 35, Figures 4, 7

Pecten (*Lyropecten*) *dilleri* Dall, Nautilus, Vol. 14, No. 10, p. 117, February, 1901.

Pecten (*Patinopecten*) *dilleri* Dall, Arnold, U. S. G. S., Prof. Paper 47, p. 62, pl. 5, fig. 2, 1906. Rio Dell, Eel River, Humboldt Co., California. "Upper Miocene or lower Pliocene". — E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 431, pl. 30, fig. 1, 1926. Near Elephant Mesa, Lower

California, Pliocene. Also earlier records.

Patinopecten dilleri Dall, Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 222, pp. 65, 83, 84, 106, 107, pl. 11, figs. 1, 9, 1950. Santa Maria district, California, Pliocene. Also p. 104, "India and Upas streets, San Diego." — Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. "San Diego formation." Also Niguel Formation and others.

Type specimen. — "Cotype" No. 164846, United States National Museum. (Arnold.)

Type locality. — "horizon of Rio Dell on the Eel River, California." (Dall.) According to Keen and Benton (Geol. Soc. Amer., Spec. Papers No. 56, p. 85, 1944), syntypes of this species are from the "[W 1/2 5, T 1N, R 1E, H], Humboldt Co." A study of the strata in the area from which the type of *Pecten dilleri* came led Ogle (309) to the opinion that "it suggests that the type must have been found in the lower part of the Rio Dell formation."

Range. — Middle Pliocene, California, and northern Lower California, Mexico. "cf." Lituya Bay, Alaska, late Tertiary (MacNeil, 1961).

Occurrence in San Diego Fm. — U.C.L.A. 307.

Original description. — Shell large, rather compressed, nearly orbicular with a relatively short, straight hinge-line, dorsally rectangular, nearly smooth, subequal ears, the posterior with three small riblets; a well marked though shallow byssal fold; and moderately thick valves. The right valve is somewhat more convex and strongly sculptured, bearing 29-30 high, narrow, T-rail-shaped ribs, flattened above, overhanging narrower, deep, nearly smooth channels; and with marked concentric imbrication, feeble on top of the ribs but articularly scaly at their sides. The sculpture of the left valve is less pronounced, hidden in the matrix, but apparently similar. Alt. 192, lat. 175, diam. about 35 mm. The lateral edges are slightly defective, the submargins very narrow. (Dall.)

Remarks. — One well preserved specimen found in the San Diego Formation is present in the collections of the University of California at Los Angeles. The record of *Pecten dilleri* from San Diego by Woodring was based upon this specimen. It is 88.6 mm long, 88.6 mm high (anterior margin slightly defective), convexity (both valves together), 17 mm. There are 27 radial ribs of which two nearest the anterior margin on the right valve are medially grooved. The riblets on the anterior ears are fine but well defined, those on the posterior ears only faintly indicated. Scaly concentric lamellae are only faintly noticeable on the right valve but on the left valve these are well developed. A portion of a right valve, 61 mm long, is present in the collection from Loc. 307 (UCLA).

On some specimens of this species from other formations, concentric lamellae may cross the ribs or only flanges may be present along the margins of the ribs on the right valve. On well preserved left valves, strong, elevated, concentric lamellae cross the ribs, or are occasionally interrupted and alternating, as shown on the illustrations of a left valve from northern Lower California by E. K. Jordan and Hertlein (1926, pl. 30, fig. 1).

A study of the species of *Lituyapecten* led MacNeil (1961, pp. 233, 235) to conclude that *P. (L.) dilleri* probably stems from *P. (L.) poulcreekensis* MacNeil (310), which was described from the upper portion of the Poul Creek Formation in Alaska of early Miocene age. He

discussed and illustrated specimens (see MacNeil, 1961, p. 235, pl. 41, figs. 4, 5; pl. 45, fig. 1) under the name of "*Patinopecten (Lituyapecten)* cf. *P. (L.) dilleri* (Dall)," "from the upper mudstone unit of an unnamed Tertiary formation, Lituya district, Alaska, USGS 7931," of Pliocene age.

Akiyama suggested possible relationship between *P. (L.) dilleri* and *P. kurosawaensis* Yokoyama (311) which was described from beds of late Pliocene age in Japan. That species is said to bear 36 to 40 round-topped ribs. No mention is made in the description of any frill-like flanges on the ribs, a shell character well developed on *P. (L.) dilleri*. Evidence of close relationship between the Japanese species and *P. (L.) dilleri* needs confirmation.

Pecten (Lituyapecten) purisimaensis Arnold (312), another member of the *P. (L.) poulcreekensis* group, is characterized by fewer (22 to 24), usually broader ribs on the right valve and narrower, sharper ribs with correspondingly wider interspaces on the left valve.

Fossils cited as "*P. dilleri* variety" by Woodring (1950, pl. 9, figs. 6-8), from the Sisquoc Formation in the Santa Maria district are characterized by the presence of riblets in the interspaces on the left valve and by minute riblets crossed by very fine lamellae in the interspaces on the right valve.

Pecten dilleri Dall was recorded by Arnold and Hannibal (313) as occurring in strata of Pliocene age in western Washington but Weaver (1943) later cited *P. coosensis* from beds of that age in both western Washington and Oregon.

Pecten (Lituyapecten) coosensis Shumard (314), bears a resemblance to *P. (L.) dilleri* in the slightly developed flanges on the ribs and in that the ribs bear one or more medial grooves toward the ventral margin, a feature well shown in the illustrations by Weaver and by Trumbull. Also a fold is present on the anterior ear of the left valve. MacNeil (1961, p. 233) suggested that *P. (L.) coosensis* is a member of the *P. (L.) yakatagensis* group.

Akiyama suggested that *P. (L.) coosensis* is closely allied with *P. nakatombetsuensis* (315) a species said to be sculptured with 29 elevated, flat-topped, squarish ribs on the right valve and 24 round topped ribs on the left valve, from the early Pliocene of Japan. Judging from the description and illustrations only, the Japanese species is quite distinct from *P. (L.) coosensis*.

Pecten dilleri has been recorded from California in Humboldt Co., Santa Barbara Co., and San Diego Co., and in Lower California northwest of Elephant Mesa. So far as known, typical specimens of this species occur only in beds of approximately middle Pliocene age.

GENUS *CHLAMYS* RÖDING IN BOLTEN

Chlamys Röding in Bolten, Mus. Boltenianum, Pt. 2, p. 161, 1798. Numerous species cited, the first two are, "*C. Cinnabarina*. Dei zinberrothe Mantel. Gmel. *Ostrea islandica*. sp. 55. Chemn. 7.t.65. fig. 615, 616. 9 St." and "*C. islandica*. Der isländische Mantel. eod. 4 St." — Meek, Rept. U. S. Geol. Surv. Terr., Vol. 9, p. 23, 1876. "*P. Islandica*, Linn . . . this shell was Bolten's first species of *Chlamys* . . . it has been cited by Herrmannsen and others as its type." — Woodring, Carnegie Inst. Washington, Publ. 366, p. 64, 1925. "Type (by subsequent designation, Dall, 1898). —

Pecten islandicus Müller." — Arkell, Palaeontogr. Soc. (London), Vol. 82, for 1928, Brit. Corall. Lamellibr., Pt. 2, p. 102, issued December, 1930. [No type cited.] — Cox, Mem. Geol. Surv. India, Palaeo. Indica, Ser. 9, Vol. 3, Pt. 4, p. 3, 1952. "Genotype. — *Pecten islandicus* Müller (1776, p. 248), Recent circumboreal; designated by A. N. Herrmannsen, 1846."

Not *Chlamys* Koch, 1801. Coleoptera. Renamed *Arthrochlamys* by von Ihering, Rev. Mus. Paulista, Vol. 6, p. 642, 1905.

Myochlamys von Ihering, An. Mus. Nac. Buenos Aires, Vol. 14 (Ser. 3^a, Vol. 7), p. 251, 1907. "Maintenant cependant ayant vérifié que les noms de Bolten ne peuvent pas être admis, je ne peux pas trouver un autre nom générique pour *Chlamys* auct., et je propose par cette raison le nom générique de *Myochlamys* n. n., pour substituer *Chlamys* Bolten."

Chlamydina Cossmann, Rev. Crit. de Paleozool., Vol. 13, Livr. 1, p. 67, January, 1909. New Name for *Myochlamys* von Ihering, 1907, not *Myochlamys* Fairman, 1876. Coleoptera.

Type species (by subsequent designation, Herrmannsen, Indic. Gener. Malacozoor., Vol. 1, p. 231, 1846). — "Typus: *Pecten Islandicus* Linn." [Müller, Zool. Danicae Prod., p. 248, 1776. "1. Hörpudiskur. Isl. R. 901. t. 10.f.5. edulis." Illustrated by Chemnitz, Syst. Conchyl.-Cab., Bd. 7, p. 314, pl. 65, figs. 615, 616, 1784. — Arnold, U. S. G. S., Prof. Paper No. 47, p. 113, pl. 45, figs. 1, 1a, 1906. These figures reproduced by I. S. Oldroyd, "The Marine Shells of the West Coast of North America," Stanford Univ. Publ. Univ. Series Geol. Sci., Vol. 1, pl. 8, figs. 1, 2, 1924, and by Korobkov, Metodicheskoe Rukovodstvo Po Tretichnym Molluskam. Plastinchatozhabernye [Lamellibranchiata], Gostoptehizdat [Publishing house], Leningrad, pl. 63, figs. 1a, 1b, 1954. See also discussion of this species by Jensen, Danish Ingolf-Exped., Vol. 2, Pt. 5, p. 15, pl. 1, figs. 4a-d, 1912. Greenland, Iceland, and the Faroes; and MacNeil, U. S. G. S., Prof. Paper 553, pp. 33-34, pl. 18, fig. 8; pl. 19, figs. 2, 5; pl. 24, figs. 12, 13, 1967.]

Range. — Early Triassic to Recent, worldwide. Recent from low tide to about 2013 meters (1100 fathoms).

Description. — Shell suborbicular to subtrigonal and higher than long, frequently slightly oblique, equivalve or one valve slightly more convex. Auricles clearly delimited from the body of the shell, unequal, the anterior ones longer than the posterior. Byssal sinus present beneath the anterior auricle; ctenolium usually developed. Cardinal crura variable in number and strength; auricular crura sometimes present, but seldom prominent. Ornamentation similar or dissimilar on the two valves, normally consisting of radial threads or ribs and thin, concentric lamellae which often form rough, scale-like projections, especially on the left valve; ornamentation on some species is almost obsolete or lacking; margin usually scalloped. (Adapted from Arkell, 1930, and Cox, 1952.)

Remarks. — *Chlamys*, on the basis of shell characters, is here used as a genus name. It is recognized, however, that on the basis of similarity of anatomy, *Chlamys* could be retained as a subgenus (316) of *Pecten*.

The genus *Chlamys*, in a broad sense, includes the majority of known species of Pectinidae. These species all possess a well developed byssal sinus but the ornamen-

tation varies from fine to coarse ribs or to mere undulations of the shell to nearly smooth unsculptured valves. Valves of some species of *Chlamys* which are nearly smooth usually retain at least some ribbing on the auricles. Some species attach themselves by a byssus to some object and move about comparatively little. Others break the attached threads and swim about freely. Some large forms lie upon the sea-bottom and in the adult stage, apparently move about but little if any. Many of the Recent species are brilliantly colored.

There is great variation in the ribbing of the *Chlamys* group as shown by Fedotov's (317) study of Recent and fossil forms of *Chlamys islandica*.

SUBGENUS *CHLAMYS* S. S.

Range. — Early Triassic to Recent.

Description. — Shell usually with the dorsal margins of the body steeply sloping and the height greater than the length; not strongly inflated. Byssal notch deep, ctenolium well developed. Ornamentation similar or slightly dissimilar in the two valves, consisting of close-set radial threads or narrow ribs, which are frequently squamose. About two pairs of not very prominent cardinal crura are present. (Cox, 1952.)

Remarks. — Ribbing on the two valves in this group is usually dissimilar, those on the right valve usually increase by dichotomization, those on the left valve by intercalation. The two valves are gently convex, sometimes the left one more so than the right one. Arkell called attention to the fact that the "internal ribs near the margin are rounded, grooved and not very prominent."

As pointed out by others, the fine, spiny ribbed forms resemble, in many features, the late Paleozoic Aviculopectinidae. They are well represented both as fossils and Recent in western North America.

Some of the characters of the shell of *Chlamys* s. s. which differ from those of the subgenus *Aequipecten* Fischer are the greater height than length, smaller apical angle, more numerous often bifurcating radial ribs and the unequal auricles. Arkell (1930, p. 102) mentioned that in *Aequipecten* "the ribs are usually fewer and far more regular, not bifurcating, while the internal ribs near the margin are prominent, flattened and marginally

pointed." Furthermore, the inner surface of the valves of *Chlamys*, except near the margin, is rippled, whereas that of *Aequipecten* has clearly defined ribs.

It is difficult, however, to determine whether some species should be assigned to the subgenus *Chlamys* s. s. or to *Aequipecten*. Staesche (1926, p. 26) believed that various groups of species referable to *Aequipecten* arose independently from time to time from *Chlamys*. He (318) assigned 25 forms from the Schwabian Jurassic to *Chlamys* and eight to *Aequipecten*. From the Jurassic of France, Dechaseaux (319) assigned 25 forms to *Chlamys* and 32 to *Aequipecten*. Some of these are now placed in different subgenera.

From a study of Recent species Dechaseaux (1936, p. 126) inferred that the presence of *Chlamys* in a fauna indicated proximity to a rocky bottom.

Chlamys (Chlamys) hastata Sowerby

Plate 33, Figures 4, 5, 6

- P[ecten]. hastatus* Sowerby, Thes. Conch., Vol. 1, p. 72, pl. 20, fig. 236, 1842. — Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "Pliocene." "well at San Diego." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. "Well-digging in stratum B²," San Diego. — Cooper, Calif. State Min. Bur. Seventh Ann. Rept. State Mineral, p. 257, 1888. "Pl. — San Diego well." — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, August, 1898. Dall's record (1874) cited. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 63, 1903. "Pacific Beach," Pliocene. — Arnold., U. S. G. S., Prof. Paper 47, p. 28, 1906. "San Diego formation" at "Pacific Beach." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 173, 182, 1912. "San Diego-Purissima." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 151, 1919. "San Diego," Pliocene. — Orcutt, quoted by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited. — Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 53, pl. 29, figs. 1, 3, 1924. "Range. Monterey to San Pedro, California." *Pecten (Chlamys) hastatus* Sowerby, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 109, pl. 11, figs. 4, 4a ("Pliocene, Deadman Island"), 1903. "Pliocene . . . San Diego

Key to Species and Subspecies of *Chlamys* s. s.

A. Interspace with minute radial or oblique groovings

- a. Interspaces with fine radial grooves; ribs even, fine, low *opuntia*
- aa. Interspaces with minute oblique groovings; major ribs consisting of a fascicle of three riblets
 - b. Each fascicle with central riblet higher and with very long spines *hastata*
 - bb. Each fascicle with three riblets of nearly equal height with spines of moderate height *hercicus*

B. Interspaces with minute reticulate, honeycomb-like sculpture

- a. Major ribs on right valve composed of 3 fascicles of nearly equal riblets *ellisi*
- aa. Major ribs on right valve simple, flattened on top
 - b. Ribs on left valve simple, not fasciculated or imbricated; ribs with honeycomb-like sculpture *jordani*
 - bb. Ribs on left valve often fasciculated and imbricated; top of ribs usually lacking honeycomb-like sculpture *rubida*

(Arnold)". — Arnold, U. S. G. S., Prof. Paper 47, p. 108, pl. 41, fig. 4 ("Pliocene, San Raphael Hills, Santa Barbara County, Cal."); pl. 42, figs. 1, 1a, 2, 2a (Recent Monterey Bay, California, 1906. "Pliocene . . . Pacific Beach, San Diego (Arnold," — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, table opp. p. 78, 1929. "San Diego Pliocene."

Pecten (Pecten) hastatus Sowerby, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 166, pl. 11, figs. 6a, 6b, 1931. Page 167. "San Diego (Dall, 1874)", "Pliocene."

Chlamys hastata Sowerby, Grau, Allan Hancock Pac. Exped., Vol. 23, p. 84, pls. 27, 28. 1959. Monterey to San Diego, California, Recent. Also Pliocene and Pleistocene.

Mimachlamys hastata Sowerby, Glibert and Van de Poel, Inst. Roy. Sci. Nat. Belgique, Mém., Deuxième Sér., Fasc. 78, p. 31, 1965. Spanish Bight (North Island), California; Pleistocene.

Type specimen. — "The only specimen we have seen is in the collection of the Rev. F. J. Stainforth." (Sowerby.) Location of type specimen unknown to the present authors.

Type locality. — No locality originally cited. Subsequently designated by Grau (1959, p. 85) as "San Diego, California."

Range. — Late Miocene (Nomland; Stanton (cf.); Addicott and Vedder); Pliocene to Recent. Recent from Monterey to San Diego, California, in 18 to 91 meters (10 to 50 fathoms).

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 105, 1132, 1400, 2028, 28892. L.A.M. 107, 122, 305. S.D. 34, 2915. U.C.L.A. 294, 2420.

Original description. — T. ovali subtrigona, sub-elongata, scabra; auriculis inaequalibus, posticis minimis, anticis magnis, scabroso-sulcatis: valva sinistra, costis 8, inaequalibus, valde elevatis, angulatis; spinas numerosas, erectas, subcrispas ferentibus. Costis interstitialibus numerosis, inaequalibus, serratis: valva dextra, costis 22, angulatis, spinosis; colore rubro, intus albo. Long. 0.95; lat. 0.30; alt. 1.15; poll. (Sowerby.)

Oval, inclining to triangular, rather elongated, rough; with very unequal ears, the posterior ones being very small; the upper valve has eight unequal, elevated, angular ribs, with numerous erect, slightly curved sharp spines, and several smaller spinose ribs in the interstices. The lower valve has 22 more nearly equal ribs with more numerous and smaller spines on the angles. (Sowerby.)

Remarks. — This spiny scallop occurs in strata of Pliocene age at Pacific Beach as well as on the San Diego mesa. The largest specimen from that area which we have seen is a right valve from Loc. 2028 (CAS), Pacific Beach. It is 43.2 mm long and 48.5 mm high. Some of these specimens retain details of sculpture typical of *Chlamys hastata* with the prominent central riblet bearing long, projecting spines.

Eroded specimens of this species are often difficult to separate from similar specimens of the subspecies *C. hastata hericius*. In general, the major ribs on *C. hastata* are rather sharply defined whereas on *C. h. hericius* these are composed of a fascicle of riblets the whole with a convex outline. The right valve of *C. hastata* is sculptured with 9 or 10 paired, high, steeply sloping ribs, each bearing a row of long spines. There are 1 to 3 thread-like spiny

riblets in the interspaces. Very fine, incised groovings are present on the surface in the interspaces between the ribs. On the right valve of *C. h. hericius*, a generally more northern, larger form, there are three riblets of nearly equal size (although the central one is slightly larger) on each major rib which lend a rounded appearance to the ribs. The ribs on the left valve of *C. hastata*, 9 or 10 in number, are narrower and more steeply sloping than are those of *C. h. hericius*.

A large Recent specimen of *Chlamys hastata* in the collections of the California Academy of Sciences is 60 mm long, 63.5 mm high (dorsal-ventral), the convexity (both valves together), about 16.5 mm. The shells of this species are beautifully tinted with pink or pinkish-white or orange coloration. This scallop can either swim about or may remain attached.

The species described as *Pecten (Chlamys) lawsoni* (320) by Arnold was based upon a poorly preserved specimen from "the Pliocene at the Waldorf asphalt mine, 4 miles south of Guadalupe, Santa Barbara County", is generally relegated to the synonymy of *C. (C.) hastata*.

Adegoke (321) recently mentioned that most of the records of occurrences of *C. hastata* from the Santa Margarita Formation, of late Miocene age, are probably referable to species of *Hinnites*.

The fossil described under the name of *Pecten (Chlamys) hastatus* var. *ingeniosa* Yokoyama (322) from late Tertiary beds in Japan is a species distinct from the west American shell. Likewise, the form indicated by Slodkewitsch (323) as a questionable variety of *C. hastata* from the upper horizon of the Kavan series of Pliocene age in Kamtschatka is apparently not referable to Sowerby's species. Vaillant's record of *Pecten hastatus* from Suez later was referred by Lamy (324) to *Chlamys squamosa decorata* Jousseume.

The species described as *Pecten denticulatus* by Adams and Reeve (325), with the locality "Hab. Shores of Borneo," was believed by Bavay (326) to be a juvenile form of *Chlamys hastata* and Grau (1959, pp. 86-87) accepted this view. This assignment may be correct, especially when considering the fact that some other species described by Adams and Reeve as coming from the East Indian region are now known to be west American species. Cox (327), however, considered Bavay's assignment of *Pecten denticulatus* Adams and Reeve to *Chlamys hastata* to be very improbable and proposed a substitute name for the former, *Chlamys odontata*, because of a prior *Pecten denticulatus* von Hagenow, 1842.

MacNeil (1967, pp. 14-15) recently discussed the *Chlamys (Chlamys) hastata* group.

Chlamys (Chlamys) hastata hericius Gould

Plate 33, Figure 2

Pecten hericius Gould, Proc. Boston Soc. Nat. Hist., Vol. 3, p. 345, December 1850. — Gould, U. S. Explor. Exped. (Wilkes), Vol. 12, p. 457, 1852. Atlas, Moll., pl. 42, figs. 570, 570a, 570b, 570c, 1856. "Inhabits the Straits of De Fuca Oregon." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 63, 1903. "Pacific Beach", "Pliocene". — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 52, pl. 7, figs. 1, 2, 1924. (Copy of illustrations from Arnold, 1906, pl. 43, figs. 3, 3a). "Range. Port Althorp, Alaska, to San Diego,

California."

Pecten hericeus Gould, Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 29, 1878. "San Diego," "Later Tertiary." Page 29, "about ten miles northward from San Diego, on the seacoast", "(Stratum C)."

Pecten hastatus Sowerby, Cooper, Calif. State Bur. Min., Seventh Ann. Rept. State Mineral., p. 257, 1888, (in part, according to Arnold, 1906). "San Diego well," Pliocene. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 166, 1931 (in part, *Pecten hericeus* in synonym.).

Pecten (Chlamys) hericeus Gould, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 110, pl. 11, fig. 2 ("Pliocene, Deadman Island"), 1903. "San Diego well (Cooper): San Diego (Arnold)." — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 16, pl. 23, figs. 1, 2, 1924. (Copy of Illustrations by Arnold, 1906, pl. 43, figs. 3, 3a). Port Althorp, Alaska, to San Diego, California. — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, table opp. p. 78, 1929. "San Diego Pliocene."

Pecten (Chlamys) hastatus Sowerby var. *hericius* Gould, Arnold, U. S. Geol. Surv., Prof. Paper 47, p. 110, pl. 43, figs. 3, 3a (Recent, Puget Sound), 1906. "Pacific Beach, San Diego (Hemphill, Arnold)", "Pliocene."

Chlamys hastata hericia Gould, Grau, Allan Hancock Pac. Exped., Vol. 23, p. 87, pl. 29, 1959. Gulf of Alaska to Santa Barbara, California, Recent. Also Pliocene and Pleistocene.

Chlamys ("Chlamys") hastata hericius (Gould), MacNeil, U. S. Geol. Surv., Prof. Paper 553, p. 14, pl. 21, figs. 1, 3, 1967. Puget Sound, Recent.

Type specimen. — No. 5955, United States National Museum.

Type locality. — "Hab. Straits of De Fuca, Oregon."

Range. — Late Miocene (Arnold); Pliocene to Recent. Recent from Port Althorp, Alaska, to Santa Barbara, California, from minus tide to 146 meters (80 fathoms).

Occurrence in San Diego Fm. — C.A.S. 2028.

Original description. — T. rotundato-triangularis, equilateralis, equivalvis; valvis convexis, sub-tumidis: valva superior rosea, lineis exilibus concentricis exasperata, et costis ad 24 angulatis, alternis majoribus et spinis erectis fornicatis insculpta: valva inferior pallidior colore saturatori zonata, costis sub-equalibus spiniferis armata; natibus acutis, prominentibus; auribus obliquis valde inequalibus radiatim squamoso-striatis; intus porcellana; marginibus crenulatis, rosaceis. Long. 4 1/2; alt. 1 1/4; lat. 4 3/4 poll. (Gould.)

Remarks. — This subspecies is found only occasionally in Pliocene strata at San Diego. This paucity was noticed by Arnold and it is true of the collections which we have seen from that area.

One excellent right valve collected by F. M. Anderson at Loc. 2028 (CAS), Pacific Beach, along with typical *C. hastata*, is 53.6 mm long, and 58 mm high. This bears out Arnold's observation that fossil forms of this subspecies are generally smaller than Recent specimens. A huge Recent specimen taken by Walter Eyerdam in the Straits of Juan de Fuca, Puget Sound, Washington, was reported to be 93 mm high and 73 mm wide (see Min. Conch. Club South. Calif., No. 190, p. 18, 1959).

Chlamys hastata hericius (328) differs from typical *C. hastata* in the generally larger size, less spinose ribs and

in that the ribs of the right valve are composed of a fascicle consisting of three nearly equal, spiny riblets, the middle one slightly more prominent, the whole more convex in outline than the corresponding fascicle on *C. hastata*. There is usually a riblet in the middle of each interspace and between this and the major fascicle there are usually two smaller threads and occasionally also a finer pair of intercalaries. The ribs on the left valve also consist of a fascicle of riblets which is more convex than that of *C. hastata*. The surface in the interspaces between the ribs of *C. h. hericius* is usually sculptured with very fine oblique grooves or scratches similar to those on *C. hastata*. Grau pointed out that the shell of *C. hastata* often is oblique, whereas that of *C. h. hericius* seldom is.

Chlamys hastata hericius is a generally more northern form, at the present time occurring abundantly in Puget Sound often embedded in sponges. It has been recorded as occurring from Port Althorp, Alaska, south to Newport Bay, California, but we have not seen specimens from southern California.

The form originally described as *Pecten islandicus pugetensis* I. S. Oldroyd is similar to *C. h. hericius* but it is generally smaller, the interspaces and sometimes the entire valve bears fine honeycomb-like sculpture.

Masuda suggested that *Chlamys miyatokoensis* Nomura and Hatai (329), which occurs in beds of early Miocene age in Japan, may be an ancestral form of *C. hastata hericius*. The riblets forming the major ribs of the Japanese form are said to be divided into three subequal parts by radial grooves and there are but two or three riblets in the interspaces. Judging from the illustrations given by Masuda, the radial fasciculi appear to be less elevated into raised ribs lending an appearance of nearly equal, spiny, radial riblets over all the right valve. The anterior ears also are smaller than those on the west American form. The medial sulcation giving rise to the paired character of the ribs mentioned by Masuda also is noticeable on some west American specimens (see our plate 33, figure 2). Some of the illustrations given by Masuda bear a decided resemblance to some forms of *C. h. hericius* (see especially his plate 35, figure 9a) and his suggestion that *C. miyatokoensis* may be an ancestral form of *C. h. hericius* is plausible. The two, however, are apparently distinct forms.

Masuda (330) also mentioned similarities and differences between *Chlamys hastata hericius* and the Japanese species *C. kaneharai* Yokoyama (331). The similarities are very much less pronounced than are those with *C. miyatokoensis*.

Chlamys (Chlamys) hastata ellisi n. subsp.

Plate 31, Figures 2, 3; Plate 34, Figure 6

Description. — Shell characters similar to those of *Chlamys hastata* but differing in the presence of fine honeycomb-like tessellations covering the interspaces and sides of the ribs, but obscured on the tops of the ribs where covered by strong imbricating spinose sculpture. Length, 66 mm; height, 68.5 mm.

Type specimen. — Holotype, a right valve, Invertebrate Paleontology Collection, Los Angeles County Museum.

Type locality. — Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8,

T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U. S. G. S. topog. map, San Ysidro quad., ed. 1943).

Range. — Known with certainty only from strata of middle Pliocene age at the type locality.

Remarks. — In addition to the holotype a right valve, 31 mm high, and two small left valves, the larger one 20.8 mm high are referable to this new subspecies. The entire surface of left valves is covered with minute tessellations. This sculpture, composed of a layer of minute scaly imbrications, is usually preserved in the interspaces but sometimes covers the ribs as well. Often the scaly honeycomb-like material is mostly gone and the interspaces retain only a pattern of minute reticulation. This type of sculpture ("Gittersculptur" of Philippi (332)) is present on *C. islandica* and allied forms. It also occurs on many species in other groups of scallops, including *Manupecten*, *Patinopecten* and *Swiftopecten*. It may be a primitive character. This minute sculpture may easily disappear with erosion and it is quite possible that some fossil specimens lacking perfect preservation in the present as well as in other collections, and referred to *Chlamys hastata* or *C. h. hericius*, may represent *C. h. ellisi* n. subsp. The only reliable basis for separating the present new subspecies form *C. hastata* rests entirely on the presence and recognition of the surficial tessellated sculpture.

The minute sculpture of the present subspecies is similar to that of the form described as *Pecten islandicus pugetensis* (333). As mentioned by Gregg (334), the presence of minute tessellation was not mentioned in the original description by Oldroyd. The ribs of *C. hastata pugetensis* are more rounded than those of *C. hastata*, those on each valve are nearly equal in size, and the fasciculi are minutely spinose. The interior of Recent shells is often ornamented, especially around the ventral margin, with dark red or red-orange color.

Chlamys hastata pugetensis is generally reported to be smaller than *C. hastata*, *C. h. ellisi* n. subsp., and *C. h. hericius*. Henderson (335), however, reported a specimen 77 mm high and long from deposits of Pleistocene age on Big Hope Island in Puget Sound.

We have examined six specimens from the type lot of *C. h. pugetensis*, the largest of which is 43 mm high. The minute tessellated sculpture on some of these occurs over nearly the entire valve but disappears near the ventral margin. Four other Recent specimens from Puget Sound, in the collections of the California Academy of Sciences, likewise bear this characteristic minute sculpture. We also have seen specimens from Duxbury Reef, Marin Co., and from Monterey Bay, California, which retain traces of this tessellated sculpture. One Recent specimen from Braca Point, Washington, 51 mm high, possesses typical sculpture of *C. h. pugetensis* until it is 26 mm high and then follows sculpture of minute oblique groovings such as that on *C. h. hericius*, which it resembles in general features.

Chlamys hastata pugetensis is reported living from Sitkalidak Island, off eastern Kodiak Island, Alaska, to Newport Bay, California, from low tide to 91 meters (50 fathoms). It has been reported as a fossil by Gregg (1938) from strata of "presumably Pliocene" age, Deadman Island, San Pedro, California, and questionably by Grant and Gale (1931, p. 168) from strata of middle Pliocene age southeast of Pico Canyon, Los Angeles Co., California.

It appears that since Pliocene time the members of the *Chlamys hastata* group bearing honeycomb-like tessellations have been reduced to one subspecies, which is smaller, less numerous, and in general has become restricted to cooler waters.

Chlamys (Chlamys) jordani Arnold

Plate 30, Figure 10; Plate 32,
Figure 3 (cf.), 5, 6, 10, 12, 13

Pecten islandicus Müller, Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 29, 1878. Later Tertiary of San Diego. P. 29, on seacoast about 10 miles north of San Diego "(stratum c)." — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. Calif. State Mineral., p. 257, 1888. "Pl. — San Diego."

Not *Pecten islandicus* Müller, 1778.

Pecten (Chlamys) jordani Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 111, pl. 12, fig. 6, 7, June 27, 1903. — Arnold, U. S. G. S., Prof. Paper 47, p. 114, pl. 44, figs. 1, 1a, 1b ("Pliocene, Deadman Island, near San Pedro, Los Angeles County, Cal."), 1906. Also "Pacific Beach, San Diego (Arnold)," "Pliocene." — Arnold, U. S. G. S., Bull. 321, p. 32, pl. 14, figs. 5a, 5b, 1907. "Packards Hill". Also "Pliocene, Deadman Island, near San Pedro, Cal.; also found in the Fernando formation at Santa Barbara and elsewhere." "Pliocene." — B. L. Clark, Stratigraphy and Faunal Horizons of the Coast Ranges of California (Publ. privately), p. 28 (as "*Pecten jordani* Hertlein"), pl. 47, figs. 3, 4, (as "*Pecten (Chlamys) jordani* Hertlein"), 1929. (Copies of Arnold's illustrations, 1906). "Upper Pico formation of Ventura County," Pliocene.

Pecten jordani Arnold, McLaughlin and Waring, Calif. State Min. Bur., Map folio accompanying Bull. 69, inside of back cover, species 49, pl. 1, fig. 49, 1914. "lower San Pedro formation at Timm's Point, San Pedro, California," Pleistocene. — I. S. Oldroyd, Stanford Univ. Publ. Ser. Geol. Sci., Vol. 1, p. 55 (in part), 1924. "Pliocene of Santa Barbara, San Pedro, and San Diego." [Based upon Arnold's records. Not the record "Puget Sound," Recent.]

Type specimen. — No. 162, 522, United States National Museum.

Type locality. — "from the Pliocene of Deadman Island," San Pedro, California.

Range. — Middle to late Pliocene or early Pleistocene. Occurrence in San Diego Fm. — C.A.S. 105, 1132, 1183, 12149, 28893. L.A.M. 107, 305.

Original description. — Shell of medium size, shape of *P. hericius*, inequivalve, rather thin; right valve with twenty-five to thirty angular, smooth-topped, imbricated ribs, which become dichotomous after reaching a length of about 30 mm; interspaces deeply channeled and narrower than ribs; anterior ear imperfectly radially ribbed with six ridges, and showing elevated, concentric, incremental lines; posterior ear nearly obsolete, showing four ribs; byssal notch not deep; left valve shows twenty-five to thirty narrow, convex ribs, showing imbrications only slightly; interspaces as large as ribs; after a diameter of about 30 mm has been reached by the shell, small riblets appear in the widening interspaces; anterior ear shows five narrow, imbricated ridges, with wide interspaces; both valves show a tendency to contract suddenly at the basal

margin upon nearing completion of growth; surface of both valves covered with a minute, lattice-like sculpture, which is generally worn off on exposed portions of the shell. (Arnold.)

Dimensions. — Long. 42 mm; alt. 45 mm; diam. 15 mm; hinge 18 mm. (Arnold.)

Remarks. — Several earlier records of the occurrence of this species in Pliocene beds at San Diego appear to be based upon those of Dall, Cooper, and Arnold. Dall in 1878 cited *Pecten islandicus* from beds of Pliocene age at Pacific Beach and apparently this formed the basis of Cooper's record (1888) of that species in the Pliocene at San Diego. Arnold, 1906, indicated that Cooper's record was referable to *Chlamys jordani* Arnold.

Typical specimens of *Chlamys jordani* are quite rare. The type specimen from beds of late Pliocene or early Pleistocene age at San Pedro, California, was described as 45 mm high (336), 42 mm long; the umbonal angle approximately 95° . The valves are sculptured with 25-30 ribs which become dichotomous after reaching a length of about 30 mm. The ribs on the left valve are rather coarse and a short midrib appears in the interspaces after the valve has reached an altitude of about 30 mm. Both valves tend to contract toward the base.

Typical specimens of this species are higher than long and the general appearance is of a more slender shell than that of *Chlamys rubida*. As mentioned by Arnold, the right valve of *C. jordani* is similar to that of *C. rubida* but the ribs on the left valve are quite different. These reach to a height of about 20 to 30 mm, consist of simple, nonfasciculated, moderately coarse ribs covered with fine lattice-like sculpture but with only slight concentric imbrication.

One right and one left valve, the larger one 27.3 mm high, from Pacific Beach are smaller than the type of *C. jordani* and the ribs become dichotomous following a constriction of the shell when 20 mm high. One right and two small left valves, the largest one 17.5 mm high, from India and Upas streets in San Diego, develop a constriction when 16 mm high. The ribs and interspaces of all these valves are covered with very fine honeycomb-like reticulate sculpture.

One right and two left valves from Loc. 107 (LAM) are typical of *C. jordani* except for their larger size. The right valve is 47 mm high and has two constrictions in shell growth, one at 30 mm, and one at 42 mm. One left valve 34 mm high has a constriction at 20 mm, the other is 42 mm high (incomplete) and is gently contracted at a height of 29 mm. The ribbing on these left valves is dichotomous after the first constriction and, following this, the splitting of the ribs and the development of strong riblets in the interspaces result in more numerous finer ribs. Another feature on these left valves is a decided depression on the anterior ear where it joins the disk.

The only recent record of this species in beds of Pliocene age which we have noticed is that of Kundert (337) who cited it, provisionally, from the Los Angeles region. The specimens were not illustrated.

The specimen from beds at Timm's Point, San Pedro, California, which was illustrated by McLaughlin and Waring, is referable to *Chlamys jordani*. The specimen from the same locality illustrated by Woodring (338) differs in several important details from the type of *Chlamys jordani*. Woodring's specimen, a right valve, is

almost as long as high and the umbonal angle is about 105° rather than 95° . The left valve was not illustrated.

Recent specimens identified by I. S. Oldroyd (339) with *Chlamys jordani* are not typical of that species and appear to be referable to the form described as *Pecten (Chlamys) hindsii kincaidi* I. S. Oldroyd (340). The same is true of the specimen illustrated by Grau (341) which he cited as *Chlamys rubida jordani* in the synonymy of which he placed *Pecten hindsii kincaidi* I. S. Oldroyd.

The smaller apical angle and consequently less elongate, less discoidal shape as well as the constriction followed by splitting of the ribs are characteristic features of *C. jordani* as shown on Arnold's illustrations of the type specimen. These shell characters, in our opinion, differ sufficiently from those of the form described as *kincaidi* to justify separation of the two.

Chlamys jordani has been cited as occurring in beds of Pleistocene age at various localities in southern California from San Pedro to Santa Barbara and as far north as British Columbia (342). Most of these records are not accompanied by illustrations, consequently no opinion is here advanced concerning the probable identification of the species but it is almost certain that most of them are not typical *C. jordani*.

Chlamys durhami Adegoke (343), described from the Santa Margarita Formation of late Miocene age in the Coalinga region, based upon a specimen 14.9 mm long and 17.9 mm high, sculptured with 20 to 22 dichotomous ribs, was compared by its author with *C. jordani*.

Several species occurring in beds of late Tertiary age in the northwest Pacific and Japan are members of the *Chlamys rubida* group, to which *C. jordani* belongs. Masuda (344) pointed out the differences separating *Chlamys jordani* from *Chlamys akitaana* Yokoyama and *C. nisataiensis* Otuka, which occur in the late Tertiary of Japan.

Chlamys (Chlamys) opuntia Dall
Plate 30, Figure 5, 6

Pecten (Chlamys) opuntia Dall, Trans. Wagner Free Institute Sci., Vol. 3, Pt. 4, p. 707, pl. 29, fig. 6, April, 1898. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 113, 1903. "Found in the Pliocene at Pacific Beach, near San Diego." Also Pliocene at Packard's Hill, Santa Barbara, California. — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. 53, Pt. 1, p. 490, 1905. "Pliocene. San Diego County, California." — Arnold, U. S. G. S., Prof. Paper 47, p. 118, pl. 41, fig. 2, 1906. "Pliocene. Pacific Beach, San Diego (Hemphill; Hamlin; Arnold.)." — Arnold, in Eldridge and Arnold, U. S. G. S., Bull. 309, pp. 152, 244, pl. 36, fig. 8, 1907. "Pliocene, Pacific Beach, San Diego County." Also Santa Barbara; Third Street Tunnel, Los Angeles. — Arnold, U. S. G. S., Bull. 321, p. 32, pl. 14, figs. 3, 4, 1907. "Fernando formation, Arroyo Burro, Santa Barbara," Pliocene. — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, opp. p. 78, 1929. "San Diego Pliocene." — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 91, 1944. Earlier records cited.

Pecten opuntia Dall, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, pp. 150, 151, 1919. "San Diego." Also Fernando and Santa Barbara, Pliocene. — Carson, Pan-Amer. Geol., Vol. 43, No. 4, pp. 268, 269, 270,

1925. "San Diego fauna." Also Ventura Formation and Santa Barbara Formation, Pliocene.

Pecten (Pecten) opuntia Dall, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 165, pl. 11, fig. 3 (Calabasas quad., Ventura or Los Angeles Co.), 1931. "Type locality: Middle Pliocene of Pacific Beach, San Diego." Also other records.

Chlamys opuntia Dall, Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, 1940 (1941). "Strata at Pacific Beach." San Diego. Upper Pliocene. — Woodring, Bramlette, and Kew, U. S. G. S., Prof. Paper 207, p. 80, 1946. "Based on material from the upper Pliocene part of San Diego formation at Pacific Beach . . ." Also Lomita marl.

Type specimen. — No. 107752, United States National Museum.

Type locality. — "Pliocene of San Diego, California; Hemphill and Hamlin." Pacific Beach according to Arnold, 1906.

Range. — Middle and late Pliocene in southern California and northern Lower California. (Early Pliocene in southern California (Woodring).)

Occurrence in San Diego Fm. — C.A.S. 957, 1177, 1183, 1186. L.A.M. 107. S.D. 2931. Corner of Union and State streets, San Diego. S.U. Pacific Beach.

Original description: Allied to *P. hericeus* var. *navarchus* Dall, from which it differs by its smaller and not fasciculated radial ribs, more elongated anterior ear, more densely radially costate posterior ear, small size when adult, and by a tendency to be suddenly contracted at the basal margin on the completion of growth, somewhat as in *P. pesfelis*. Alt. 35 mm, lat. 32.5 mm. (Dall.)

A supplementary description by Arnold follows: Shell averaging about 35 millimeters in altitude, slightly shorter than high, subequivalve, equilateral (except for ears), both valves nearly flat until altitude of about 20 to 25 millimeters is reached, when they grow more convex; contracted at basal margin when adult; sides only slightly concave above. Right valve with 40 to 60 subequal, narrow, imbricated, more or less dichotomous ribs, which are separated by channeled interspaces about equal in width to the ribs; hinge line about two-fifths as long as disk; anterior ear much produced, sculptured by about six prominent, sharply imbricated radials, and imbricating incremental lines; byssal notch quite prominent; posterior ear nearly obsolete, radially and concentrically sculptured; whole surface of disk and ears sometimes microscopically checkered or tessellated. Left valve similar to right.

Dimensions. — Alt. 43 mm; long. 40 mm; hinge line 16 mm; diameter 12 mm; umbonal angle 78°. (Arnold, 1906.)

Remarks. — Several specimens, mostly single valves, typical of this species, are represented in collections from the San Diego Formation which we studied. A left valve from Loc. 107 (LAM), is 38.4 mm long and 43.6 mm high. Some specimens are more rounded than others. A left valve illustrated by Grant and Gale is 67 mm long and 69 mm high. The fine, uniform, non-fasciculated radial ribs are quite different from any other west American Pliocene species.

Some authors have considered this species to be a member of the *Chlamys islandica* group. It somewhat resembles some fine-ribbed variants of that group but the San Diego fossil is easily separable by its finer, even

ribbing, slightly smaller umbonal angle, generally smaller size and tendency to constriction toward the ventral margin of adult forms. These features serve to separate it from forms of *C. rubida* and its close relatives.

The ribbing and the umbonal angle of *C. opuntia* are similar to those features on *C. hertleini* Loel and Corey (345), which was described from beds of early Miocene age. One decided difference in the two species is in the outline of the posterior ears. The posterior ears on *C. opuntia* slope obliquely downward from the hinge line whereas those on *C. hertleini* are squarely truncated.

Chlamys tamurae Masuda and Sawada (346), compared by its authors with *C. opuntia*, differs in that the surface of the left valve (and to a less degree the right valve) is folded forming low, broad corrugations. Furthermore, the illustration (see their fig. 12a) shows that the major ribs are divided toward the ventral margin of the right valve, a feature only occasionally present on *C. opuntia*.

In addition to the San Diego Formation in which the type specimen was found, *Chlamys opuntia* also has been recorded from beds of late Pliocene age north of Simi Valley, in upper Pico beds in Ventura Co., in Temescal Canyon near Santa Monica, in beds encountered in the Third Street Tunnel and elsewhere in Los Angeles, and in the Tijuana-Rosarito Beach area in northwestern Lower California. It also has been recorded from strata at Santa Barbara and in the Lomita Formation near San Pedro. These latter beds have been considered to be of late Pliocene age by some writers and early Pleistocene age by others. Grant (347) considered the Lomita Formation to be of late Pliocene age and he suggested that the sediment was deposited perhaps at depths of 30 to 90 meters (100 to 300 feet) and that the temperature was about 15° to 17° C. (60° to 62° F.)

Chlamys (Chlamys) rubida Hinds

Plate 35, Figures 6, 8

Pecten rubidus Hinds, Zool. Voy. Sulphur, Moll., Pt. 3, p. 61, pl. 17, fig. 5, 1844 (January, 1845, on cover). Not *Pecten rubidus* Martyn, Univ. Conch., 1784. [Nomenclatorially unavailable. See Opinion 456 Internatl. Comm. Zool. Nomencl., 1957.]

Pecten hindsii Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 606, August, 1864. Page 645, as *Pecten hastatus* ? var. *Hindsii*. Reprint in Smithsonian Misc. Coll., No. 252, pp. 92, 131, 1872. New Name for *Pecten rubidus* Hinds, not *Pecten rubidus* Martyn, 1784. Cited as occurring at Puget Sound; Vancouver Island; Straits of San Juan de Fuca, and adjoining shores. — I. S. Oldroyd, Stanford Univ. Pub. Univ. Ser. Geol. Sci., Vol. 1, p. 53, pl. 7, figs. 3, 4, 1924. (Copy of figures by Arnold, 1906). "Bering Sea to San Diego, California."

Pecten (?var.) *Hindsii* Carpenter, Proc. Acad. Nat. Sci. Philadelphia, Vol. 17, p. 58, April, 1865. "Hab. — In sinu Pugetiano juniorem legit U. S. E. E., adultum Kennerley: in insula Vancouver legit Lord."

Pecten hericeus var. *navarchus* Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 708, April, 1898. (New name for *Pecten rubidus* Hinds, 1844, not *Pecten rubidus* Martyn, 1784). "San Diego, California, at Pacific Beach, Hamlin," "Pleistocene" [Pliocene, according

to Arnold].

Pecten hastatus Sowerby var. *navarchus* Dall, Arnold, U. S. G. S., Prof. Paper 47, p. 112, pl. 43, figs. 1, 1a, 1b (Recent, Puget Sound), 1906. "Pliocene . . . Pacific Beach, San Diego. (Hamlin)." Also earlier records.

Pecten (Chlamys) hastatus Sowerby var. *hindsii* Carpenter, Arnold, U. S. G. S., Prof. Paper 47, p. 111, pl. 32, figs. 2, 2a (Recent, southeast Alaska), 1906. Pliocene to Recent.

Pecten (Chlamys) hindsii Carpenter, I. S. Oldroyd, Publ. Puget Sound Biol. Sta. (Univ. Washington), Vol. 4, p. 17, pl. 23, figs. 3, 4, 1924. (Copies of figures by Arnold, 1906). "Bering Sea to Cape San Lucas, Lower California" [Not the record "Cape San Lucas, Lower California."]

Pecten (Chlamys) hindsii navarchus Dall, I. S. Oldroyd, Puget Sound Biol. Sta. (Univ. Washington), Vol. 4, p. 17, pl. 26, figs. 2, 3, 1924. (Copies of figures by Arnold, 1906). "Bering Sea to San Diego, Calif."

Pecten hindsii navarchus Dall, I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 54, pl. 4, figs. 2, 3, 1924. (Copies of figures by Arnold, 1906). "Bering Sea to San Diego, California." Also Pleistocene.

Pecten (Pecten) islandicus Müller variety *hindsii* Carpenter, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 163, 1931. "Middle Pliocene; Pacific Beach, San Diego (Hamlin in Arnold)."

Pecten (Chlamys) rubidus Hinds, K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 69, pl. 3, figs. 4-6, 1958. [Carpenter's species discussed.]

Chlamys rubida Hinds, Grau, Allan Hancock Pac. Exped., Vol. 23, p. 76, pl. 24, 1959. "Bering Sea to Monterey, California. Also Pacific coast of Japan, as far south as 42° N." "Just below low tide to 100 fathoms." Also Pliocene and Pleistocene.

Chlamys (Chlamys) rubida Hinds, MacNeil, U. S. G. S., Prof. Paper 553, p. 21, pl. 20, figs. 7, 9; pl. 22, figs. 7, 8, 1967. Earlier records cited.

Type specimen. — Location unknown (Palmer, 1958). Originally in British Museum (Natural History).

Type locality. — "Inhab. Alaska, North-west America. At a depth of thirty-three fathoms."

Range. — Middle Pliocene to Recent. Recent from Bering Sea to Monterey (Grau), to Santa Rosa Island (Yates (348), California. Recent from just below tide to 183 meters (100 fathoms).

Occurrence in San Diego Fm. — C.A.S. 105, 957, 1132, 28893. L.A.M. 107. S.D. 54.

Original description. — Testâ subtrigono-orbiculari, inaequaliter duplo-convexâ, inaequiauriculatâ subtenui; valvâ sinistrâ convexâ, costis parvis numerosissimis, serratis, in fasciculos duarum triumve alternatè aggregatis, rufis, interstitiis pallescentibus; valvâ dextrâ subconvexâ, albidâ, costis majusculis, aggregatis; auriculis sulcatis, posticâ parvâ, obliquâ; intus albâ. (Hinds.)

Remarks. — The right valve of *C. rubida* is sculptured with about 26 radial ribs which are wider than the interspaces, flattish-topped, smooth, and usually dichotomous. The interspaces are narrow, channeled, and sculptured with fine reticulate honeycomb-like tessellations. The left valve is sculptured with narrow, fasciculated ribs which are crossed by fine concentric imbrications, the interspaces

are sculptured similar to those on the right valve. The ribs on the right valve increase by bifurcation, those on the left, at later stages of growth, by intercalation. The sculpture of this species is quite variable.

Recent specimens of *C. rubida* are often about 60 mm high but we have seen fossil specimens 70 mm high.

One large right and one left valve, and several smaller ones, of *C. rubida* are present in the collections from the San Diego Formation. The largest is a left valve, 59.9 mm long and 64.3 mm high, Cat. No. 4736 (SD), from India Street near Spruce Street, San Diego.

The radial sculpture on some valves in the present collection from Loc. 107 (LAM) is similar to that of the species of late Pliocene age described by Waterfall as *Pecten (Chlamys) islandicus picoensis* (349), and *Pecten (Chlamys) venturaensis* (350). Grant and Gale believed that the variation in sculpture in a series of *C. "hindsii"* is such as to embrace the forms named by Waterfall. MacNeil (1967, p. 28), however, considers *C. (C.) picoensis* to be a valid species, with two subspecies which were originally described in Japan.

Typical specimens of *C. rubida* differ from *C. islandica* in the generally smaller size, often less numerous primary ribs, and especially in the smaller posterior ears.

The shell of *C. rubida* differs from that of *C. jordani* in the fasciculate rather than simple ribs on the left valve, usually the lack of honeycomb-like tessellation on the tops of the ribs, and usually greater size.

Chlamys rubida usually has been cited in west American literature under the name of *Pecten* or *Chlamys hindsii*. Carpenter proposed a new name for the species described by Hinds and stated (1864, p. 606), "'*Pecten rubidus*, Hds.' Vane. Is., Lyall. [Hind's type in Br. Mus. appears the ordinary form, of which *P. hastatus* = *hericeus* is the highly sculptured var. This shell, which is more allied to *Islandicus*, may stand as *P. Hindsii*.] (351)" In the same publication (p. 645) he stated, "*Pecten* (?var.) *Hindsii*. Broader; ribs close, small, smooth, bifurcating. Passes from *hastatus* toward *Islandicus*." The following year Carpenter (1865, p. 58) gave the dimensions as "Long. 1.6, lat. 1.7, alt. .57", presumably referring to "Poll" (Pollex) as used on page 54. This indicates a height (beak to base) of approximately 40.51 mm.

The original illustration of *Pecten rubidus* is that of the exterior of a left valve, the ribs of which are fasciculated and crossed by fine concentric imbrications. The color is pink with concentric zones of lighter color. This illustration bears a resemblance to Arnold's illustration (1906, pl. 43, fig. 1a) of "*Pecten hastatus* Sowerby var. *navarchus* Dall." Carpenter (1864, p. 645) in a comparison with *P. hastatus* mentioned "In var. *rubidus*, Hds. (non Mart.), the ribs are equal, not serrated."

Palmer (1958, p. 70) called attention to the fact that the name *Pecten hindsii* Carpenter was based upon a specimen collected by Dr. Lyall at Vancouver and that Carpenter thought that this specimen was not identical with *Pecten rubidus* Hinds. She illustrated three right valves in the collection of the Redpath Museum which Carpenter identified as "*Pecten Hindsii* Cpr. = *rubidus*, H. C. Sitka." Unfortunately, the lack of left valves in the Redpath collection makes impossible comparison with the original illustration of the left valve of *P. rubidus* shown by Hinds.

Through the courtesy of F. Stearns MacNeil we have had the opportunity to examine the valves from the Red-

path Museum. The major ribs on these right valves are flattish and rather smooth on top and dichotomous toward the ventral margin. A right valve (see our pl. 35, fig. 8) from Loc. 107 (LAM) from the San Diego Formation is quite similar to the specimen illustrated by Palmer on her plate 3, figure 6. A similar development of ribbing is present on the form described as *Pecten (Chlamys) hindsii kincaidi* I. S. Oldroyd (352) from Puget Sound. The type of that species is a suborbicular shell which has flattish smooth topped ribs on the right valve and round topped ribs with only faint intercalaries on the left valve.

According to Palmer the type specimens of both *P. rubidus* and *P. hindsii* cannot be found. Considerable variation in sculpture is revealed in a series of specimens of this species complex and the relationship of the two is not definitely known at the present time. The specimens identified by Carpenter as "*Pecten hindsii*," illustrated by Palmer, furnish some justification for retaining this form as a subspecies of *C. rubida* and this interpretation of Carpenter's species was proposed by MacNeil (U. S. G. S., Prof. Paper 553, p. 22, pl. 18, figs. 4, 6; pl. 19, figs. 1, 3, 4, 6; pl. 20, figs. 5, 6; pl. 21, fig. 4; pl. 22, figs. 1, 2; pl. 24, figs. 1, 8, 9, 1967). The two forms apparently represent extreme variants in the fine and coarse character of the ribs. The variation in sculpture of the fossils from the San Diego Formation is such that we assign to them the earliest name proposed for this group, at least until the relationship of the variants of this species complex is better known.

A right valve from the Gubik Formation, of Quaternary age in northern Alaska, which MacNeil (353) illustrated under the name of "*Chlamys hindsii*" was later described as *Chlamys (Chlamys) beringiana colvillensis* MacNeil (1967, p. 26, pl. 18, figs. 5, 7).

Pecten clemensae and *Pecten newcombi* of I. S. Oldroyd (354), *nomina nuda*, may be referable to *C. rubida* or to *C. rubida hindsii* or to the form described as *C. kincaidi*.

In the Japanese region, specimens referred to "*Chlamys islandica hindsii*" have been illustrated by Kira (355), and by Oyama and Takemura (356). According to Kuroda and Habe (357), this species occurs on the Pacific Ocean side of Japan from 42° to 55° North Latitude. We have not studied a series of specimens of the Japanese form but illustrations of specimens referred to *C. hindsii* from that region do not agree in detail with west American forms identified under that name. The record of Dautzenberg and Bavay (358) of *C. "hindsii"* in the Sulu Archipelago in the East Indies is referable to some other species (see Grau, 1959, p. 77).

The larger shell and flattish radial ribs on the right valve which are broader than their interspaces are features separating *C. rubida* from *C. imanishii* Masuda and Sawada (339) which was described from beds of Pliocene age in Japan.

Chlamys ingeniosa tanakai Akiyama (360) bears a resemblance to some forms of *C. rubida* as mentioned by Akiyama but we have not had specimens for careful comparison.

In addition to the occurrence of *Chlamys rubida* in strata of Pliocene age at San Diego, it was reported from Fourth and Broadway in Los Angeles by Willett (361), from the Ventura region by Waterfall (as *Pecten (Chlamys) islandicus picoensis* and *P. (C.) islandicus venturaensis*),

and from the Ohlson Ranch Group in Sonoma Co. by Peck (362). Nomland (363) reported it as *Pecten hastatus hindsii* from the *Pecten coalingaensis* zone of the Etchegoin Formation. Stewart (364) later reported fragments of "*C. cf. C. islandicus* (Muller)" from the *Acila* zone in the San Joaquin Formation in Kettleman Hills, but he did not record *C. rubida* from that area.

SUBGENUS *ARGOPECTEN* MONTEROSATO

Argopecten Monterosato, Jour. de Conchyl., Vol. 37 (Sér. 3, Vol. 29), No. 1, p. 20, 1889. Several species cited including "*Argopecten solidulus*, Reeve (*Pecten*, 1853). — Pl. 33, fig. 155. (Hab. ?) = *P. philippii*, (non Michelotti, 1839, espèce fossile) Récluz, 1854 = *P. commutatus*, Monterosato, 1875. C'est aussi le *P. gibbus*, Philippi (non Lamarck). — Espèce Méditerranéenne et des Canaries." — Grau, Allan Hancock Pac. Exped., Vol. 23, p. 93, 1959. [Not "Type-species: *Pecten commutatus* Monterosato, 1875, p. 6." Concerning Grau's citation of type species see Keen, Veliger, Vol. 2, No. 4, p. 101, 1960.] — Waller, Jour. Paleo., Vol. 43, Suppl. to No. 5 (Paleo. Soc., Mem. 3), p. 32, 1969. Type, *Pecten solidulus* Reeve.

Plagioctenium Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 696, April, 1898. "Type *P. ventricosus* Sby." — Tucker-Rowland, Mém. Mus. Roy. d'Hist. Nat. Belgique, Deuxième Sér., Fasc. 13, p. 32, 1938. "Type. — '*Pecten*' *ventricosus* Sowerby = *C. gibbus circularis* Sowerby, by original designation, Dall, 1898."

Type species (by subsequent designation, Monterosato, Journ. de Conchyl., Vol. 47, No. 3, p. 193, 1899). — "Type: *P. solidulus*, Reeve = *P. philippii*, Recluz (non Michelotti) = *P. commutatus*, Monts." Illustrated by Reeve, Conch. Icon., Vol. 8, *Pecten*, sp. 155, pl. 33, fig. 155, August, 1853. "Hab. ?)" — Kobelt, Syst. Conchyl. — Cab. von Martini und Chemnitz, Bd. 7, Abt. 2, *Spondylus* und *Pecten* p. 219, Taf. 58, fig. 8, 1888. [Copy of Reeve's illustration.] — Waller, 1969, p. 33, pl. 1, figs. 11, 12, 14, 15 (illustrations of holotype).

Range. — Early Miocene to Recent, worldwide in shallow, warm temperate and tropical marine waters.

Description. — Suborbicular, thick, sometimes large, equiconvex (right valve usually deeper) and with a tendency to oblique growth in adult; auricles large and nearly equal in length; ribs numerous, usually undivided, rounded or often squarish, crossed by concentric imbrications which are concave dorsally, or the ribs are frequently smooth; upper valve of Recent shells often richly colored with red or purple blotches.

Remarks. — Many American species of *Argopecten* have appeared in the literature under *Aequipecten* and *Plagioctenium*. This subgenus differs from *Aequipecten* in that the valves are nearly equally convex, the ribs and interspaces usually lack well developed radial lirae and there is a tendency toward obliquity in adult shells. Waller (365) published an extensive report dealing especially with the east American members of *Argopecten*.

The type species of *Argopecten*, *Pecten solidulus* Reeve, was based upon a juvenile shell. This species has been confused with *Pecten commutatus* Monterosato, a name proposed for *Pecten philippii* Récluz, 1853 (not *Pecten philippii* Michelotti, 1839), a Mediterranean species.

More recently, Dr. F. K. North examined the type specimen of *P. solidulus* and found it to be quite distinct from *P. commutatus*. Dollfus (386) placed Reeve's species in the synonymy of "*Pecten (Chlamys) flabellum*" Gmelin, a west African species. Waller (1969, p. 33) believes that *P. solidulus* is probably referable to *P. circularis* Sowerby.

The shape, ribbing and coloration shown by Reeve's illustration of *P. solidulus* are similar to juvenile forms of *Pecten gibbus* as mentioned by Reeve.

It is unfortunate that the type species of *Argopecten* is based upon a juvenile shell, and information concerning the locality from which it came is lacking. However, the type specimen is preserved in the British Museum and its shell characters appear to be referable to one of the members of the well known *C. gibba-circularis* group. For that reason we have referred several west American species to *Argopecten* in the synonymy of which we include *Plagiectenium* which is better known for this group but which was published later than *Argopecten*.

Argopecten includes, among others, the well known late Cenozoic American *C. circularis-gibba-irradians* group. It is well represented in the Caribbean region where F. and H. Hodson recorded subspecies of *C. circularis* from the Miocene and the Pliocene of Venezuela. Other species occur in the late Cenozoic of the Atlantic and Gulf coasts of eastern United States as well as in the Antilles and northwest Africa. Probably some species in other regions may be referable to this subgenus. Speciation in this group progressed rapidly during the Pliocene period.

The earliest representative of *Argopecten* recorded from western North America is *Chlamys (Argopecten) neahensis* Arnold (367) from beds of middle Miocene age in Washington. We have examined a cast of the type specimen and we agree with Arnold's conclusions concerning its similarity to *C. circularis*. We find no reason to place it doubtfully in the synonymy of a species of *Lyropecten* as was done by Grant and Gale (1931, p. 184). Other than inspection of this cast we have not seen specimens of this species. Weaver (1943), however, reported it from the general area from which the type came. This is the only species reported up to the present time from the Miocene of western North America which is definitely referable to *Argopecten* but this subgenus was represented by a number of species during Pliocene time in southern California and Lower California and in more

southern regions. At the present time two species (*C. purpurata* and *C. circularis*) and one subspecies (*C. circularis aequisulcata*) live in tropical and subtropical west American waters. Other species live in the western Atlantic, west Africa, and elsewhere.

From the known occurrences of species, one may infer that *Argopecten* had its origin in tropical or temperate waters in early Miocene time.

Chlamys (Argopecten) abietis abbotti n. subsp.

Plate 34, Figure 5; Plate 36, Figures 1, 6

Type specimen. — Holotype in the type collection of the San Diego Society of Natural History.

Type locality. — From cut in exposure at Frontier Housing Project, Loma Portal, San Diego, California; Patrick Hanratty collector, April, 1945.

Additional localities in San Diego Fm. — C.A.S. L.A.M. 302A, P.87: No. 8325. S.D. 409.

Description. — Shell large, thick, both valves highly convex, somewhat elongated posteriorly; hinge line long, a little over two thirds the length of the valves. Right valve with 21 radial ribs which are high, narrowly flat-topped and steeply sloping until the valve is about 70 mm high, then becoming lower and broadly rounded; the sides of the ribs and the interspaces are ornamented with close-set fringing lamellae; anterior ear sculptured with 4 or 5 fine radial riblets, a well developed byssal notch present; posterior ear faintly radially striated and with lines of growth which reveal a shallow sinuation. Left valve with ribbing similar to that of the right except that the ribs are narrower and more triangular, the anterior ear with a shallower notch and with faint traces of fine riblets. Inner margin of valves scalloped by the corresponding ribs and interspaces on the exterior. Dimensions: length 129.0 mm, height 118.0 mm, convexity (both valves together), 64.0 mm, length of hinge line 88.0 mm.

Remarks. — The shell characters of this new subspecies appear to be intermediate between those of *Chlamys (Argopecten) abietis* E. K. Jordan and Hertlein (368) and those of *C. (A.) circularis aequisulcata* Carpenter (369). This new subspecies differs from *C. (A.) abietis* in the deeper notch under the right anterior ear, in the more widely spaced ribs and by the more flattened character of the ribs toward the ventral

Key to Species and Subspecies of *Argopecten*

A. Valves highly and nearly equally convex

- a. Major ribs of right valve (22) with small riblet at base on each side *cricellus*
- aa. Major ribs of right valve (18 to 21) lacking riblet at base
 - b. Ribs on left valve rounded *circularis*
 - bb. Ribs on left valve triangular *abbotti*

B. Valves moderately convex, the left decidedly more so

- a. Ribs 18 to 22; shell of moderate size

- b. Ribs 18 to 21; ribs decidedly widened toward ventral margin *invalida*
- bb. Ribs 21 to 22; ribs not decidedly widened toward ventral margin
 - c. Ribs low, rounded, subobsolete toward ventral margin *subdola*
 - cc. Ribs squarish, high, retaining this character to ventral margin *callida*
- aa. Ribs 24 to 27; shell large, coarse, thick *hakei*

margin of the left valve. It differs from *C. (A.) circularis aequisulcata* in the larger, thicker shell, longer hinge line, more triangular shape of the ribs in the early stages of growth but which become rounded and flattened toward the ventral margin on the right valve, and also in the more highly convex left valve with narrower interspaces between the ribs.

The rotund appearance of large specimens of this new subspecies lends a general resemblance to *C. (A.) hakei* Hertlein but it may be separated from that species by the fewer ribs (21 or 22 rather than 24 to 27) which are triangular until the shell is about 70 mm high and then become broader and flatter toward the ventral margin.

A large, thick, left valve in the collections of the Los Angeles County Museum, collected by Charles Sternberg at 32nd Avenue and Woolman Street, San Diego, is 105 mm long, 96 mm high, the convexity about 27 mm. It is sculptured with 21 ribs. The interior is reddish-brown in color especially the ventral half of the valve. The shell is partially covered with hard, gray, fine grained sandstone. Small oysters are attached to the exterior of the valve as might occur if the empty shell lay upon the sea bottom for a time before it was covered with sediment. The very large size of this valve and the traces of coloration on the interior are similar to those of *C. (A.) c. aequisulcata* Carpenter but the size and thickness correspond more with those of *C. (A.) abietis abbotti* and we refer it provisionally to this subspecies.

Two specimens from Loc. 595 (UCLA), about two miles north of Somis, Ventura Co., California, in a *Pecten* reef apparently near the base of the Long Canyon Member of the Las Posas Formation, of late Pliocene age, are quite similar to the type specimen of *C. (A.) abietis abbotti* but the ribs are slightly broader. The larger specimen is 141.5 mm long, 132.6 mm high, the convexity (both valves together), 61 mm. A smaller specimen collected with the two large fossils from Ventura County, is 74 mm long, 69.6 mm high, the convexity (both valves together), 34 mm. The ribs on this specimen, especially on the left valve, are triangular with fringing lamellae, corresponding in every way with typical *C. (A.) abietis* of the same size from Lower California.

This subspecies is named for Clinton G. Abbott, former Director of the Museum of the San Diego Society of Natural History, whose encouragement to the authors during the preparation of the early portion of this memoir is greatly appreciated.

Chlamys (Argopecten) circularis Sowerby
Plate 32, Figures 4, 15, 16

Pecten tumidus Sowerby, Proc. Zool. Soc. London for 1835, p. 109, October 9, 1835. "Hab. ad Sanctam Elenam et ad Salango, Columbiae occidentalis. Found in sandy mud at from six to ten fathoms."

Not *Pecten tumidus* Turton, 1822.

Not *Pecten tumidus* Hartmann in von Zieten, 1833.

Pecten circularis Sowerby, Proc. Zool. Soc. London for 1835, p. 110, issued October 9, 1835. "Hab. ad Sinum Californiae. (Guaymas)." "Found in sandy mud at a depth of seven fathoms." — Sowerby, Thes. Conch., Vol. 1, *Pecten*, p. 51, pl. 12, fig. 23, 1842.

Pecten ventricosus Sowerby, Thes. Conch., Vol. 1, p. 51 pl. 12, figs. 18, 19, 26, 1842. A new name for *Pecten*

tumidus Sowerby, 1935. Not *Pecten tumidus* Turton, 1822, nor *Pecten tumidus* Hartmann in Zieten, 1833. — Reeve, Conch. Icon., Vol. 8, *Pecten*, species 31, pl. 7 figs. 31a, 31b, 1852. Not the locality "Philippine Islands."

Pecten (Plagiectenium) circularis Sowerby, Arnold, U. S. G. S., Prof. Paper 47, p. 125, pl. 42, figs. 3-6; pl. 44, figs. 6, 6a, 6b, 7, 1906. "Pliocene (?). Cholas Valley, near San Diego (Stearns)." Also Pleistocene. Recent from the Gulf of California to Santa Elena, Ecuador. — E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 439, 1926. "The San Diego Pliocene at Pacific Beach, near San Diego, California."

Aequipecten (Plagiectenium) circularis Sowerby, Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 72, fig. 132, 1958. Gulf of California to Paita, Peru. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 163, pl. 19, figs. 2, 2a, 2b, 1961. Recent, Lower California to northern Peru.

Chlamys (Argopecten) circularis Sowerby, Grau, Allan Hancock Pacific Exped., Vol. 23, p. 97, pl. 32, 1959. Cedros Island, Lower California, Mexico, to Paita, Peru, and the Galápagos Islands, at depths from 4 feet to 75 fathoms. Also, ?Pliocene and Pleistocene.

Type specimen. — No. 1950-11-14.18.19., British Museum (Natural History).

Type locality. — "Hab. ad Sinum Californiae. (Guaymas)." "Found in sandy mud at a depth of seven fathoms."

Range. — Middle Pliocene to Recent. Recent from Cedros Island, Lower California, Mexico, to Bayovar, Peru, and the Galápagos Islands, in 1 to 137 meters (1 to 75 fathoms). "Found on rock, gravel, sand, sandy mud bottoms; associated with kelp, corallines or gorgonians." (Grau.)

Occurrence in the San Diego Fm. — C.A.S. 1132, 1137. L.A.M. 305, 305A, 320, 320A. S.D. 412. U.C.L.A. 306.

Original description. — *Pect. testâ suborbiculari, tumidâ, subaequali, aequilaterali, fusco alboque variâ, auriculis magnis, subaequalibus; costis radiantibus octodecim interstitiis latioribus, arcuatim striatis; valvâ alterâ sulcis profundioribus: long. 1.5, lat. 0.8, alt. 1.4 poll.* (Sowerby.)

Remarks. — About 45 specimens, mostly single valves, are here referred to *Chlamys circularis*. A right valve from Loc. 320 (LAM), near the Mexican boundary, is 84 mm long, 83.5 mm high, the convexity (one valve) about 28 mm. Another right valve from Loc. 1137 (CAS), corner of Logan Avenue and 31st Street, San Diego, is 49.5 mm long. Many smaller, well preserved valves also occur with these larger specimens. An interesting feature of many of these fossils is that they retain traces of coloration.

The larger valves are definitely referable to *Chlamys circularis*. In the smaller valves, there is much variation in the convexity, the width of the interspaces between the ribs and in the height and degree of rounding or flattening of the tops of the ribs. Many of the valves to a height of about 35 mm are very convex, the ribs are high and flat-topped and rather closely spaced. These closely resemble Arnold's illustration (1906, pl. 44, fig. 7) of the type of *Pecten compactus* Dall which is now generally placed in

the synonymy of *C. circularis*. Other larger ones resemble Arnold's illustration of *C. circularis* (on his plate 42, fig. 3). Large specimens of *C. circularis* from the Gulf of California are about 66 mm long.

Some of the small specimens resemble *C. (A.) circularis aequisulcata* Carpenter (370), but the shells are somewhat thicker, the ribs are wider and the coloration appears to have been more pronounced than on the subspecies. A comparison of these small fossils with a series of specimens of Recent *C. (A.) circularis* from tropical west American waters reveals similar convexity and ribbing in the early stages of the Recent species.

Recent adult specimens of *C. (A.) circularis aequisulcata* differ from typical *C. (A.) circularis* in the larger, flatter, and thinner shell as well as in the narrower ribs and less brightly colored shell.

Chlamys circularis is very similar to the Recent east American species, *C. gibba* Linnaeus (371), but differs in details, especially in the decided angulation delimiting the posterior ear from the disk on the right valve. Davenport (372) made a comparative study of a large number of specimens of these two species from the east and west coasts of North America and found some difference in the convexity and in the less obliquity of the west coast form. The two species are undoubtedly members of a closely related group but we do not consider them to be identical.

Several species and subspecies allied to the *C. gibba-circularis* group have been described from strata of late Miocene and Pliocene age in southeastern United States. These have been discussed by Tucker-Rowland, by Mansfield, and by Waller. Weisbord (373) recently discussed thirteen species and subspecies of this group.

Some of the fossils from the San Diego formation closely resemble some specimens of the form described as *Pecten (Plagiectenium) calli* Hertlein (374) from beds of Pliocene age at Bahía Tortolo (Turtle Bay), Lower California. The record of this form from the San Diego Pliocene, mentioned by E. K. Jordan and Hertlein, is referred by us to juvenile *C. circularis*. Typical specimens of the form *C. c. calli* possess very highly arched umbos, squarish ribs on the right valve and fine, high ribs on the left valve. There is also a tendency for the valves to develop a length greater in proportion to the height. Durham (375) mentioned this tendency in *C. circularis* occurring in Pliocene beds in the Gulf of California region. The valves of *C. circularis calli* are more elongated and the ribs are more numerous and narrower than those of *C. circularis bramkampii* Durham (376) described from the Carrizo Creek region in Imperial County, which has about 19 ribs.

In general appearance and in degree of globosity, some of the smaller specimens from San Diego resemble *C. eldridgei* Arnold (377) which was described from beds of late Pliocene age in San Joaquin Valley, California. The fossils from San Diego have thinner shells, which lack constrictions, the ribs are more numerous, often a little more widely spaced and the crenellations along the ventral margin of the interior are less consistently and deeply grooved than those of *C. eldridgei*. The ribs on some of the left valves of *C. eldridgei* are shallowly medially grooved toward the ventral margin but this feature is lacking on the valves from San Diego.

Some of the present specimens bear a resemblance to *Chlamys deserti* Conrad (378) but differ from typical

specimens of Conrad's species. The original description of *Chlamys deserti* was based upon a left valve with 23 ribs. Arnold (379) illustrated specimens from Carrizo Creek, the type locality of *C. deserti*, and mentioned the correct number of ribs.

Grant and Gale (1931, p. 212) cited the number of ribs on the *deserti* group "usually 18 or 19", and on typical *deserti* 15 to 19. Woodring and Stewart (1941, p. 91) stated that *C. deserti* had fewer ribs than *P. impostor* which originally was described as possessing 21 to 24. It appears obvious that some of the specimens attributed to *C. deserti* are not referable to it. Judging from the original description given by Conrad, the left valve illustrated by Arnold (1906, pl. 26, fig. 3), the illustrations of Nomland (1917, pl. 6, figs. 1, 1a, 1b), those of Hanna (1926, pl. 25, figs. 1, 2, 3), and of Durham (1950, pl. 11, figs. 5, 6) correctly delineate typical specimens of Conrad's species.

The present fossils from San Diego are more elongate than typical *C. deserti*, they have fewer ribs, the submargins are wider and not sculptured with riblets and the ears are more concave. They are referable to the variable species, *C. circularis*.

Several members of the *C. circularis* group have been described from strata of Miocene age. The species described as *Pecten (Plagiectenium) neahensis* by Arnold (1906, p. 87, pl. 15, fig. 2, 2a, 2b) from beds of Miocene age at Neah Bay, Washington, has narrower ribs and a longer hinge line than *C. circularis*. The type specimen is definitely referable to *Argopecten* as mentioned in our discussion of that subgenus.

Three subspecies of *C. circularis* were described by F. and H. Hodson, from beds of Miocene and Pliocene age in the Caribbean region. These were described as *Pecten circularis cornellanus* (380), Miocene; *Pecten circularis venezuelanus* (381), Miocene and Pliocene; and *Pecten circularis caucanus* (382) of Pliocene age. These were said to generally differ from typical *Chlamys circularis* in details of sculpture but that intergradation exists with that species. Another member of this group described as *Pecten (Plagiectenium) demiurgus* by Dall (383) (to which species Grant and Gale referred some west American records of *C. circularis*) from strata of late Miocene age in Trinidad, has higher, narrower umbones and the ribs are said to be wider and more closely spaced than those of the Recent west American species.

Chlamys (Argopecten) callida Hertlein
Plate 32, Figures 9, 11

Pecten (Plagiectenium) callidus Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 1, p. 22, pl. 5, figs. 1, 3, 5, 6, July 21, 1925. — E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 437, 1926. "San Diego Pliocene of Pacific Beach near San Diego, California." Also Cedros Island and Turtle Bay, Lower California, Pliocene.

Pecten (Aequipecten) purpuratus Lamarck variety *callidus* Hertlein, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 211, pl. 5, fig. 4 (Fernando Pass, Los Angeles Co., 1931. "San Diego (Stanford collection).") Pliocene.

Type specimen. — No. 53, Stanford University, Department of Geology, Type Collection.

Type locality. — "Cedros Island, Lower California." "Salada, Pliocene."

Range. — Middle Pliocene of southern California and northern Lower California.

Occurrence in San Diego Fm. — C.A.S. 105, 1138, 1413, 1414, 12145. L.A.M. 122, 127, 305.

Original description. — Shell of medium size, the valves moderately arched. Right valve ornamented by about 21 or 22 rather high, flat-topped, radiating ribs separated by narrower interspaces, tops of ribs smooth, but sides and interspaces sculptured by fine, sharp lamellae; anterior and posterior margins sculptured by concentric lines of growth only; ventral margin rounded; ears unequal, the anterior with a large byssal notch and ornamented by about five or six radiating riblets crossed by concentric lines of growth; the posterior sculptured by several radiating riblets. Left valve more convex than right and somewhat one-sided in appearance, with sculpture quite similar to that of right valve except that the interspaces are slightly wider; anterior ear carrying a small, rounded notch and ornamentation consisting of small, radiating riblets and concentric lines of growth; posterior ear sculptured much as the anterior. Altitude 55 mm; longitude 55 mm; diameter 19 mm; apical angle of valves approximately 105° . (Hertlein.)

Remarks. — Several specimens of *Chlamys callida* are present in collections from Pliocene beds at Pacific Beach. One of the largest of these is 55.5 mm long; 53.5 mm high; convexity (both valves together) 19.6 mm; length of hinge line 30.5 mm; umbonal angle 105° .

The shell of this species is characterized by the gently convex right valve and sculpture consisting of 21 to 22 well developed flat-topped ribs which are separated by narrower interspaces. The left valve is more convex than the right, but is similarly sculptured except that the ribs are narrower and separated by wider interspaces.

The outline and general sculpture of this species is similar to that of *Chlamys subdola*, but it differs from that species in the much higher flat-topped ribs which retain this character to the ventral margin.

The greater size, greater number of flat-topped ribs which retain this character to the margin, the lack of interrupted concentric zones of growth and the greater umbonal angle, are features which serve to separate *C. callida* from *C. invalida*.

To the north of San Diego, *Chlamys callida* has been reported by Grant and Gale as occurring in beds of Pliocene age in the Los Angeles region. To the south it is known to occur at Cedros Island and at Bahía Tórtolo (Turtle Bay) on the west coast of Lower California. It has been recorded by Vokes (384) as occurring in the Gloria Formation of middle Pliocene age and in the Infierno Formation of late Pliocene age in the Santa Rosalia district on the east coast of Lower California. The specimen cited by Hanna and Hertlein under the name of this species from San José Island in the Gulf of California is not typical of *C. callida*.

Chlamys (Argopecten) ericellus Hertlein
Plate 32, Figure 7

Pecten (Plagiotenum) ericellus Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 18, No. 5, p. 215, pl. 24, figs. 10, 11 (in No. 8), April 5, 1929. — Keen and Bentson, Geol.

Soc. Amer., Spec. Papers No. 56, p. 85, 1944. Original record cited.

Type specimen. — No. 2998, California Academy of Sciences, Department of Geology, Type Collection.

Type locality. — "Pacific Beach, San Diego, California." "San Diego Pliocene."

Range. — Known only from the type locality.

Occurrence in the San Diego Formation. — California Academy of Sciences: Loc. 1132, Pacific Beach (Sternberg Loc. 34).

Original description. — Shell small, moderately convex; hinge line straight. Right valve ornamented by about 22 subrounded, fairly low radiating ribs which are separated by narrower interspaces; two tiny midribs are present along the base of the sides of the major ribs; ribs and interspaces crossed by concentric lines of growth; anterior and posterior margins ornamented by concentric lines of growth; ventral margin rounded; ears unequal, the anterior with a well-defined byssal notch, and sculpture of about five or six radiating riblets crossed by incremental lines; the posterior ear sculptured by about four or five radiating riblets crossed by lines of growth, no notch present. Altitude 28 mm; longitude, 29.1 mm; diameter of right valve approximately 7.5 mm; apical angle in right valve approximately 94° . (Hertlein.)

Remarks. — The shell of this species is characterized by its narrow, subrounded ribs, narrow interspaces, and by the presence of two tiny riblets, one at the base of each side of most of the major ribs. In some of the interspaces toward the lateral margins only one riblet, or in some cases, none is present.

This form appears to be a member of the *Chlamys circularis* group. It differs from *C. circularis* in the smaller posterior ear, more numerous, narrower ribs and interspaces, and in the presence of the riblets in the interspaces toward the ventral margin.

Grant and Gale (1931, p. 219) stated that this form could be matched by juvenile specimens of *Chlamys circularis aquisulcata* Carpenter. However, they cited it with question in the synonymy of "*Pecten (Aequipecten) gibbus* variety *circularis* Sowerby." Comparison of the type specimen of *C. (A.) ericellus* with a series of specimens of *C. circularis* and its subspecies *C. circularis aquisulcata* of comparable size, reveals differences sufficient in our opinion to justify assignment of specific status to *C. (A.) ericellus*.

Chlamys (Argopecten) hakei Hertlein
Plate 33, Figure 10

Pecten (Plagiotenum) hakei Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 1, p. 18, pl. 4, figs. 1, 3, July 21, 1925. — E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 440, pl. 31, figs. 1, 2 ("Cedros Island" and "Turtle Bay", Lower California; Pliocene), 1926.

Pecten (Aequipecten) purpuratus Lamarck variety *hakei* Hertlein, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 209, pl. 8, fig. 3, 1931. Type specimen illustrated. Earlier records cited. Cited from "San Diego formation (Hertlein and Grant)," also from Pliocene of Lower California and Ventura Co., California.

Type specimen. — A right valve, No. 40, Stanford

University, Department of Geology, Type Collection.

Type locality. — "Turtle Bay, Lower California," Salada, Pliocene.

Range. — Middle Pliocene of southern California and northern Lower California.

Occurrence in San Diego Fm. — L.A.M. 124. S.D. 4413.

Original description. — Shell moderately arched, coarse and thick, slightly longer than high. Right valve ornamented by about 23 or 24 rounded to slightly flat-topped ribs, separated by narrower, round-bottomed interspaces, both the interspaces and ribs crossed by concentric incremental lines, and, in some cases, by rather strong lines of growth; anterior ear with a large byssal notch, and sculpture consisting of about five or six radiating riblets, crossed by concentric incremental lines; anterior and posterior margins of valves smooth except for concentric incremental lines; ventral margin rounded; posterior ear ornamented by about eight radiating riblets and by lines of growth, the posterior edge of the ear forming nearly a right angle with the hinge line. Left valve convex, higher at the umbo than the right valve, and ornamented by about 24 or 25 squarish, flat-topped, rounded ribs, separated by narrower, round-bottomed interspaces, the whole valve sculptured by concentric lines of growth; ears slightly concave, ornamented by about six or seven radiating riblets. Altitude 90 mm, longitude 95 mm, diameter of right valve approximately 15 mm; apical angle of right valve, approximately 114° . (Hertlein.)

Remarks. — A large, well preserved specimen of *Chlamys hakei* was collected at Pacific Beach by Dr. E. C. Wilson, San Diego Society of Natural History. It is 152 mm long, 135 mm high, the convexity (both valves together) 55 mm. It is sculptured with about 27 radial ribs and it agrees in all shell characters with specimens from beds of Pliocene age on Cedros Island. A large left valve in the collections of the San Diego Society of Natural History, from Juniper and Boundary streets, San Diego, is 160 mm long, 142 mm high, convexity approximately 35 mm. A fragment of an imperfectly preserved left valve in the collections of the Los Angeles County Museum, which came from strata 15 feet below Snyder's Continuation school in San Diego, is provisionally referred to *C. hakei*.

This species is characterized by its large, thick, coarse valves which are sculptured with 24 to 27 subrounded radial ribs.

The shell of this species can be separated from other somewhat similar west American species of *Argopecten* by its large size when adult and by the more numerous subrounded radial ribs. In the number of ribs it is exceeded by *Chlamys (Argopecten) evermanni* E. K. Jordan and Hertlein (1926, p. 439, pl. 27, fig. 1) which has 30 to 31 flattish topped ribs separated by very narrow interspaces. *Chlamys hakei* differs from *C. cristobalensis* Hertlein (385) in the much wider and less elevated ribs. *Chlamys hakei* differs from *C. purpurata* Lamarck (386) now living from Paita, Peru, to Valparaiso, Chile, in the generally larger size, larger ears, generally more numerous, rounded ribs which are separated by narrower interspaces. The ribs on the right valve of *C. purpurata* are flat-topped and on both valves the ribs are separated by rather deeply grooved interspaces, those on large left valves often with an interstitial riblet.

Chlamys hakei can be easily separated from *Chlamys*

(*Lyropecten*) *cerrosensis* by the more numerous ribs, lack of coarse hinge teeth, lack of midrib in interspaces and also by the fact that the ears on the left valve slope downward from the margin rather than forming a right angle.

In addition to the present record of *Chlamys hakei* in beds of Pliocene age at San Diego, it occurs at Cedros Island and at Bahía Tórtolo (Turtle Bay), Lower California. Grant and Gale recorded this species as occurring in beds of Pliocene age one and one half miles west of Somis in Ventura Co. but that record needs substantiation.

We are uncertain what species is represented by the record of "*Pecten purpuratus* var." cited by Woodring (387) from beds of Pliocene age in Temescal Canyon, Los Angeles Co., California, or by records of that species from the same county which were listed by Oakshott (388), and by Winterer and Durham (389). Vokes (390) reported "*Aequipecten purpuratus*" from strata of late Pliocene age and "*Aequipecten cf. purpuratus*" from beds of Pleistocene age in the Santa Rosalía region in Lower California. However, Durham, 1950, did not record that species in collections from the Gulf of California region studied by him nor, more recently, did Emerson and Hertlein (Trans. San Diego Soc. Nat. Hist., Vol. 13, No. 17, pp. 333-338, 1964). It appears certain that records of *C. purpurata* from western North America are referable to some other species.

Chlamys (Argopecten) invalida Hanna

Plate 33, Figures 1, 3, 8

Pecten (Plagioclenium) cooperi Arnold, U. S. G. S., Prof. Paper 47, p. 124, pl. 49, figs. 2, 3, 4, 1906. San Diego Formation, Pacific Beach, San Diego, Pliocene. — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 83, 1944. Arnold's record cited.

Pecten cooperi Arnold, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 151, 1919. "San Diego." Pliocene.

Not *Pecten cooperi* E. A. Smith, Fauna and Geography of Maldive and Laccadive Archipelago, Vol. 2, Pt. 2, Moll., p. 621, pl. 36, figs. 15-18, 1903. Felidu Atoll, Maldive Islands, in 1 to 35 fathoms.

Pecten invalidus Hanna, Proc. Calif. Acad. Sci., Ser. 4, Vol. 13, No. 10, p. 177, March 18, 1924. New name for *Pecten cooperi* Arnold, 1906, not *P. cooperi* E. A. Smith, 1903. — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 88, 1944. "[San Diego,] Pliocene. Pacific Beach, San Diego Co."

Pecten (Plagioclenium) invalidus Hanna, E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 441, 1926. "San Diego upper Pliocene of southern California." Also records from Lower California.

Pecten (Aequipecten) deserti Conrad variety *invalidus* Hanna, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 213, 1931. "Pacific Beach, San Diego (Arnold; Hertlein and Grant)." Pliocene.

Aequipecten circularis invalidus Hanna, Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, 1940 (1941). Pacific Beach, San Diego, California, Pliocene.

Aequipecten invalidus Hanna, Vedder, U. S. G. S., Prof. Paper B-400, p. B327, 1960. "San Diego formation." Also Niguel Formation and others.

Type specimen. — No. 8, Stanford University, Department of Geology, Type Collection.

Type locality. — "San Diego formation (Pliocene), Pacific Beach, San Diego County, Cal."

Range. — Middle Pliocene of San Diego, California, and northwestern Lower California.

Occurrence in San Diego Fm. — C.A.S. 104, 105, 1130, 1132, 1138, 1179, 1199, 1399, 1413, 12145, 34025. L.A.M. 122. U.C.L.A. 302, 2420.

three miles south of La Jolla, Pacific Beach; Locs. 105; 1130, 1138, [Sternberg's Loc. 3]; 1199; 12145; 35025 Pacific Beach; Loc. 1132, above Loc. 1130; Loc. 1179, upper portion of lower beds exposed in Pliocene section

Original description of *Pecten (Plagiactenium) cooperi* Arnold. — Shell averaging about 30 millimeters in altitude, slightly longer than high, both valves moderately convex, disks slightly obliquely produced posteriorly, moderately thick; disk generally characterized by several more or less prominent concentric zones of interrupted growth, which show as color bands even on the fossil shells; sides nearly straight; margins serrate. Right valve with 18 to 20 flat-topped, squarish ribs, which tend to flatten out and become more convex topped in the later stages of growth; interspaces narrower than the ribs, and crossed on the bottom by numerous, fine, sharp, incremental lirulae, which become obsolete on the ribs excepting in the later stages of growth; hinge line somewhat more than one-half length of disk; anterior ear slightly produced and ornamented by 4 or 5 prominent radials and numerous incremental lines; byssal notch deep and sharply defined; posterior ear slightly truncated, and sculptured by obsolete radials and fine incremental lines. Left valve similar to right, except that the ribs are narrower and the interspaces correspondingly broader. Dimensions: Alt. 30 mm; long. 31 mm; hinge line 17 mm; diameter 12 mm; umbonal angle 95°. (Arnold.)

Remarks. — A number of specimens all from Pacific Beach, the type locality of *Chlamys invalida*, agree in all shell characters with the type specimen.

Valves of this species are characterized by their low convexity and by the character of the ribs, 18 to 20, which are square in the early stages but which widen out and become more convex toward the ventral margin. The interspaces often are ornamented with well developed concentric imbrications.

A typical right valve from Loc. 1179 (CAS), Pacific Beach, is 35.2 mm long, 33.5 mm high, convexity (one valve) 9 mm, umbonal angle 95°. Two large right valves, from Loc. 105 (CAS), the larger 47.9 mm long and 46.8 mm high, agree with valves of *Chlamys invalida* except that they are larger and have a greater number of ribs, 21 to 22. These valves appear to be referable to large gerontic forms of *C. invalida*.

The smaller shell, more rounded outline, fewer ribs which become broader and more rounded toward the ventral margin, occasional concentric zones of interrupted growth, and smaller umbonal angle are features which serve to separate this species from *Chlamys callida*.

The generally smaller more orbicular shell and fewer ribs which become decidedly broader and more convex but not obsolete near the margin are characteristics which serve to separate *C. invalida* from "*Aequipecten*" *antonitaensis* Durham (391) which was described from beds of middle Pliocene age at Punta Santa Antonita on

the east coast of Lower California.

Chlamys invalida has also been reported from Cedros Island and the west coast of Lower California. Records of it in the Gulf of California region are, in most cases, open to doubt. Specimens from beds of Pliocene age in the Los Angeles region which were attributed to this species by Grant and Gale (1931, pl. 5, figs. 5a, 5b, 5c, 6a, 6b, 6c) are not typical of *C. invalida* but bear a greater resemblance to some forms of *C. deserti* Conrad or of *C. circularis*.

Chlamys (Argopecten) coopericellus Ferreira (392), described from strata of early Miocene age in Brazil, was compared by its author with "*C. (A.) cooperi* (Arnold, 1906)" [= *Pecten invalidus* Hanna]. A small riblet is present in the interspaces between the ribs of the Brazilian species and in this and in other details it is quite distinct from *C. invalida*.

Kryshtofovich (393) reported "*Pecten cooperi*" as occurring in the "Upper oil bearing series" of Pliocene age on Sakhalin Island, but that record doubtless is referable to some oriental species.

Chlamys (Argopecten) subdola Hertlein
Plate 30, Figures 7, 8; Plate 35, Figures 2, 5, 9

Pecten (Plagiactenium) subdolos Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 1, p. 20, pl. 5, figs. 2, 4, 7, July 31, 1925. — E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 443, 1926. "San Diego upper Pliocene of Pacific Beach, Calif." — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 94, 1944. Earlier records cited. — Hertlein and Grant, State Calif. Div. Mines, Bull. 170, Chapt. 2, p. 60, 1954. "San Diego formation."

Pecten (Aequipecten) purpuratus Lamarck variety *subdolos* Hertlein, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 211, pl. 5, fig. 1 (west of San Fernando Pass, Los Angeles Co.), 1931. "San Diego (Hertlein; Jordan and Hertlein; Hertlein and Grant)."

Pecten subdolos Hertlein, Hertlein and Grant, Calif. Jour. Min. Geol., Rept. State Mineral. 35, p. 69, 1939. Upper beds in Pliocene section at Pacific Beach. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, pp. 57, 59. Pacific Beach; Market Street one-tenth mile east of Euclid Avenue, San Diego, Pliocene.

Pecten (Argopecten) subdolos Hertlein, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 50, pl. 23, figs. a, b, 1968. Pacific Beach, Pliocene.

Type specimen. — No. 51, Stanford University, Department of Geology, Type Collection.

Type locality. — "Pacific Beach, San Diego, California." "San Diego, Pliocene."

Range. — Middle Pliocene of southern California and northern Lower California.

Occurrence in San Diego Fm. — C.A.S. 104, 105, 1132, 1182, 1183, 1401, 1413, 12145, 28880, 33334. L.A.M. 107, 122, 127, P.87: No. 58339. S.D. 5, 80, 365, 408. U.C.L.A. 300, 302, 2359.

Original description. — Shell of medium size, the valves moderately convex. Right valve ornamented by about 21 rounded, radiating ribs which become broader toward the ventral margin, the ribs separated by round-bottomed, narrower interspaces, the whole surface

ornamented by very fine radial striations and by concentric lines of growth; anterior and posterior margins sculptured only by concentric incremental lines; ventral margin rounded; ears unequal, the anterior with a well defined byssal notch, and sculpture of about six radiating riblets crossed by incremental lines; the posterior also sculptured by about six or seven slight radiating riblets crossed by lines of growth, a very slight notch present. Left valve more arched than right and somewhat one-sided in appearance, ornamented by about 21 rounded, radiating ribs separated by round-bottomed interspaces about as wide as the ribs, the whole surface finely longitudinally striate and crossed by concentric lines of growth; ears slightly concave, the posterior sculptured by very slight radiating riblets and concentric lines of growth, the anterior with a rounded notch, the surface sculptured by a few slight radiating riblets and by concentric growth lines, the ornamentation indistinct on weathered specimens. Altitude 50 mm, longitude 50 mm, diameter approximately 17 mm, apical angle in each valve approximately 105° . (Hertlein.)

Remarks. — This species occurs rather abundantly in the San Diego Formation, especially at Pacific Beach. One of the largest specimens from Loc. 1401 (CAS), south slope of Mount Soledad, is 64.2 mm long, 61 mm high, convexity (both valves together), 23 mm, length of hinge, approximately 32 mm, umbonal angle 105° .

The shell of *Chlamys subdola* resembles that of *C. callida*, with which it occurs, in outline and in general pattern of sculpture. It differs from the latter species in possessing a thinner shell, in the low rounded ribs, the presence of radial striae on the disk, and weaker sculpture on the ears.

Specimens of *Chlamys subdola* closely resemble some individuals of *Chlamys impostor* Hanna (394). We have examined a large series of *C. impostor* and it is evident that there is considerable variation in that species with respect to number of ribs (20 to 24), the elevation and degree of roundness of the ribs and in the umbonal angle. The largest specimens usually do not exceed 46 mm in altitude.

In comparison to *Chlamys impostor*, the shell of *Chlamys subdola* is thinner, it attains a greater size (altitude 50 to 61 mm), the ribs, of which there are usually fewer, are flatter and become broader toward the ventral margin, the ears are a little larger, and the ribs on the left valve are finer.

Grant and Gale (1931, p. 214) considered *Chlamys impostor* to be a variety of *Chlamys deserti* Conrad (395), whereas Woodring and Stewart (396) considered it to be a subspecies of *Chlamys circularis* Sowerby. Whatever the true relationship may be, there is a striking resemblance between some specimens of *Chlamys impostor* and those of *C. subdola*. However, the differences observed in series of the two lead us, at least for the present, to retain *C. subdola* as a species rather than a subspecies of *C. impostor*. Grant and Gale considered *Chlamys subdola* to be a variety of *C. purpurata* Lamarck. The differences between the two are obvious.

"*Aequipecten*" *revellei* Durham (Geol. Soc. Amer., Mem. 43, Pt. 2, p. 63, pl. 9, figs. 6, 9, 1950) described from strata of Pliocene age on Monserrate Island, in the Gulf of California, bears a resemblance to *C. subdola*, but differs in the more rounded outline and proportionally

longer hinge line.

There is a general similarity in the outline and sculpture between *Chlamys subdola* and *C. eborea senescens* Dall (397) and the form *walkerensis* Tucker (398), which Tucker-Rowland later placed in the synonymy of *C. eboreus senescens* Dall. There are differences between the east and west coast species, such as in the shape of the posterior ear, and the relationship, if any, is unknown. Another species bearing a resemblance to *C. subdola* is *C. imitata* Weisbord (399) which was described from strata of Pliocene age in Venezuela.

In addition to its occurrence in the San Diego Formation, *Chlamys subdola* has been recorded by Grant and Gale (1931, p. 211) from "middle Pico" beds west of Fernando Pass in Los Angeles County, California. To the south it occurs abundantly at Cedros Island and it also occurs in Pliocene beds on the adjacent mainland of Lower California. Vokes (400) recorded it as occurring in beds of Pliocene age in the Santa Rosalía area on the east coast of Lower California but later authors have not reported it from the Gulf of California region.

SUBGENUS *LEPTOPECTEN* VERRILL

Leptopecten Verrill, Trans. Connecticut Acad. Arts Sci., Vol. 10, Pt. 1, p. 69, June, 1890. — Grau, Allan Hancock Pac. Exped., Vol. 23, p. 105, 1959. Type designation by monotypy.

Type species (by original designation). — "Type, *C. monolimeris* (Conrad)" [= *Pecten monolimeris* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 238, pl. 18, fig. 10, 1837. "Inhabits with the preceding"] [which is, "Inhabits below the efflux of the tide near Sta. Diego and Sta. Barbara."] "The young occasionally found attached to *Fuci* by a slender byssus." Illustrated by I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 57, pl. 40, figs. 1 and 2, 1924. [These are not copies of Conrad's illustrations although stated to be so by Oldroyd.] See also Grau, 1959, p. 110, pl. 35, fig. 2.

Range. — Early Miocene to Recent. Recent from the intertidal zone to 219 meters (120 fathoms).

Description. — Shell thin, translucent, oblique, broadly rounded, with strong, rounded radial ridges or folds, like corrugations, which appear in reverse on the interior surface. The internal ribs are not angulated by a deposit of the shell, nor distinctly thickened. Margin with broad scallops. The exterior surface is covered with fine divergent camptonectes sculpture, both on the ribs and intervals. The ribs do not increase in number with age, but become broader and more flattened. Auricles large and broad, thin, corrugated. Byssal notch large and deep. Pectinidial teeth prominent. Hinge-plate thin and but little differentiated. Cardinal ridge thin and small, close to the ligament, crossed by fine incisions. The resillal pit is small, close to the ligament, crossed by fine incisions. The risillal pit is small, but projects beyond the thin hinge-plate in the left valve. (Verrill.)

This is a peculiar group, remarkable for its thin but strongly corrugated oblique shells, with fine camptonectes sculpture. (Verrill.)

Remarks. — About a dozen west American late Cenozoic species and subspecies are referable to *Leptopecten*. These small, thin, oblique shells differ sufficiently from those of *Aequipecten* and *Argopecten* to justify the

recognition of *Leptopecten* as a distinct subgenus.

The *Pecten andersoni* group which occurs in beds of Miocene age in western North America can be assigned to *Leptopecten*. Several species in the late Cenozoic of northern South America and in the Caribbean region also are referable to this subgenus. Among these are *Pecten atlanticola* Anderson and *P. mactoskeyi* Anderson from Miocene beds in Colombia, and *P. bavaei* Dautzenberg and *Pecten linki* Dall living in the Caribbean.

Some of the species assigned to *Leptopecten* attain considerable size. Grau (written comm., March 1, 1965) mentioned that a large specimen of *C. (L.) monotimeris* is from off an oil well platform off Summerland, California, is 49 mm long and 43 mm high.

Pecten (Leptopecten) praevalidus E. K. Jordan and Hertlein (401) described from beds of Pliocene age near Bahía Tortolo (Turtle Bay), Lower California, attains a length of 50 mm, height 48 mm, and length of hinge line, 48 mm. In general appearance this species is remarkably similar to *Chlamys sacyi* Cossmann and Peyrot (402) described from beds of Burdigalian, Miocene age in France. The latter species is the type species of *Antipekten* Cossmann in Cossmann and Peyrot (403), which appears to differ from *Aequipekten* in the obliquity of the hinge line, larger ears, and in the unequal size of the ribs on the left valve.

Key to Species of *Leptopecten*

- A. Ribs narrow, sharply topped;
interspaces wider than the ribs *bellilamellata*
- B. Ribs squarish, flat topped;
interspaces about as wide as the
ribs *latiaurata*

Chlamys (Leptopecten) bellilamellata Arnold
Plate 32, Figures 1, 2, 8

Pecten (Chlamys) bellilamellatus Arnold, U. S. G. S., Prof. Paper 47, p. 108, pl. 41, figs. 6, 6a, 7, 7a, 1906. — Arnold, in Eldridge and Arnold, U. S. G. S., Bull. 309, p. 252, pl. 40, fig. 14, April, 1907. "Pliocene, Pacific Beach, San Diego." — Arnold, Proc. U. S. Nat. Mus., Vol. 32, No. 1545, p. 546, pl. 50, fig. 14, June 15, 1907. "Pliocene, Pacific Beach, San Diego." — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 81, 1944. Records by Arnold cited.

Pecten (Aequipekten) bellilamellatus Arnold, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 205, 1931. "Pliocene: Pacific Beach, San Diego (Arnold)."

Type specimen. — No. 35, Stanford University, Department of Geology, Type Collection.

Type locality. — "Pliocene at Pacific Beach, San Diego, California.

Range. — Middle Pliocene at Pacific Beach, San Diego, California; Cedros Island, Bahía Tortola (Turtle Bay) and Elephant Mesa, Lower California.

Occurrence in San Diego Fm. — C.A.S. 1400. S.D. 331.

Original Description. — Shell averaging about 18 millimeters in altitude, about as long as high, equivalve, both valves moderately convex, inequilateral; sides nearly

straight; margins not serrate. Right valve with 15 or 16 prominent narrow, sharply convex-topped ribs with sloping sides; interspaces much wider than ribs, with narrow, flat bottoms; surface sculptured by numerous, regular, equidistant, thin, concentric, imbricating lamellae, which cut squarely across the bottoms of the interspaces, curve convexly toward the umbo on the sides of the ribs, and loop gracefully downward away from the umbo on the tops; hinge line equal to the length of the disk; ears equal in length; anterior ear convexly truncated, separated from the disk by a deep, sharply defined, byssal notch, and sculptured by fine, regular, incremental lamellae and five or six subequal radials; posterior ear acutely pointed, radially striate, and with incremental sculpture similar to but not quite as prominent as that of the anterior. Left valve similar to the right; anterior ear more prominently sculptured, both radially and concentrically, than the posterior. Dimensions. Alt. 18 mm, long. 18 mm, hinge line 18 mm, diameter 8 mm, umbonal angle 100°. (Arnold.)

"This species is characterized by its small size when adult, long hinge line, narrow, sharply topped ribs and beautifully curved incremental lamellae". (Arnold.)

Remarks. — The characters enumerated by Arnold easily serve to separate this species from *Chlamys (Leptopecten) latiaurata* Conrad and its subspecies *C. (L.) latiaurata delosi* Arnold. (404).

Two left valves from strata of Pliocene age at Pacific Beach in the collections of the California Academy of Sciences are referable to *Chlamys bellilamellata*. The larger one is 16.6 mm long, possesses 14 high, sharp-topped radial ribs which show traces of concentric imbrications. The other is a small valve 12.8 mm long which has but 13 narrow, sharp-topped, widely separated ribs which likewise show traces of concentric imbrications.

A small right valve from Loc. 331 (SD), from near the Mexican boundary is 14.6 mm long and 13.7 mm high, appears to be referable to the present species. There are about 13 sharply rounded ribs which are wider than the interspaces. The posterior ear is imperfect but the growth lines indicate an auricle similar to that of *C. (L.) bellilamellata*.

Three small valves and one large right valve 16.3 mm high and 16.5 mm long were collected in the upper portion of the Pliocene strata exposed at Pacific Beach.

Webb (405) reported the occurrence of this species in beds of Pleistocene age at Point Loma Peninsula, California, but we have not seen specimens.

Chlamys (Leptopecten) desultoria Weisbord (406), described from beds of Pliocene age in Venezuela, was compared by its author with *C. (L.) bellilamellata* from which it differs in possessing a radial thread in the interspaces.

Chlamys (Leptopecten) latiaurata Conrad
Plate 35, Figures 1, 3

Pecten latiauratus Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 238, pl. 18, fig. 9, 1837.

Pecten tunica Philippi, Abbild. u. Beschreib. Conchyl., Bd. 1, Heft 4, *Pecten*, p. 100 (2), pl. 1, fig. 3, January, 1844. "Habitat ad Insulas Sandwich." [Locality erroneous.]

Pecten latiauritus Conrad, Kobelt, Conchyl. -Cab. von

Martini und Chemnitz, Bd. 7, Abt. 2, p. 203, pl. 54, figs. 7, 8, 1888. "an der Westküste von Nordamerika, besonders an Californien." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 57 (under section *Leptopecten*), pl. 22, fig. 2, 1924. "Monterey, California, to the Gulf of California," Recent. [Reproduction of Conrad's original figure of *P. latiauratus*.]

Pecten (Chlamys) latiauritus Conrad, Arnold, U. S. G. S., Prof. Paper 47, p. 115, pl. 46, figs. 2, 2a, 3, 3a, 1906. Pliocene to Recent.

Chlamys (Leptopecten) latiaurata Conrad, Grau, Allan Hancock Pac. Exped., Vol. 23, p. 107, pl. 35, fig. 1, 1959. Earlier records cited.

Type specimen. — Two syntypes in British Museum (Natural History), Nos. 55.3.14.53 and 61.5.20.89 (A. M. Keen, Veliger, Vol. 8, No. 3, p. 169, 1966).

Type locality. — "Inhabits below the efflux of the tide near Sta. Diego and Sta. Barbara." [California.] "Type locality: San Diego, California" (Grau).

Range. — Middle Pliocene to Recent. Recent from Point Reyes, California, to Cape San Lucas, Lower California, Mexico. Also Guadalupe Island. Reported from 1 foot (minus tide) to 229 meters (125 fathoms). Found attached to rocks or pilings in shallow water; in deeper water on rock, shale, gravel, or sand bottoms, often attached to calcareous algae. (Grau.)

Occurrence in San Diego Fm. — S.D. 331. U.C.L.A. 312.

Original description. — Shell inequilateral, thin, compressed; ribs fourteen, flattened on the back, slightly sulcated; interstices transversely striated; ears very wide, unequal, both acutely angulated at the extremity; colour reddish brown and white, variegated or spotted. (Conrad.)

A series of specimens reveals that the number of ribs may vary from 12 to 16. Some of these may be faintly medially sulcated. A faint intercalary riblet may be present in the interspaces especially on large specimens.

Remarks. — Three right and one very small left valve of this species are present in the collection from Loc. 312 (UCLA). The largest specimen, a right valve, is 16.9 mm long and 17.5 mm high. One small right valve 14.6 mm long was collected at Loc. 331 (SD). A large Recent specimen of this species in the collections of the California Academy of Sciences collected by H. N. Lowe at Long Beach, California, is 33.8 mm long, 31 mm high, convexity (both valves together), 11.9 mm, length of hinge, 28 mm.

This is the first record of the occurrence of *Chlamys (Leptopecten) latiaurata* in the San Diego Formation. Woodring (407) questioned Arnold's record of the occurrence of this species in the Third Street tunnel in Los Angeles. However, it has been recorded from beds of Pliocene age elsewhere. Arnold (408) reported it from the "lowest Merced horizon developed in the Santa Cruz quadrangle" and E. K. Jordan and Hertlein (409) recorded it from beds of Pliocene age at Cedros Island and at Bahía Tórtolo (Turtle Bay), Lower California.

Chlamys (Leptopecten) latiaurata differs from *C. (L.) monolimeris* Conrad in the squarish ribs rather than rounded undulations of the shell.

A species described from the Gulf of California, *Aequipekten (Leptopecten) camerella* Berry (410), is said to resemble *C. (L.) latiaurata* but "differing chiefly in its

smaller size, plumper more rounded form, smooth intervals between the radii of the disk, and lighter coloring."

Ferreira (411) reported a species under the name of "*Chlamys (Leptopecten)* cf. *latiaurata*" from beds of early Miocene age in Brazil. Judging solely from the illustrations, the Brazilian form resembles some species of *Leptopecten* described from the late Cenozoic of the Caribbean region more closely than it does the west American species.

Aequipekten (Leptopecten) cracens Olsson (412), described from strata of Miocene age in Ecuador, is sculptured with 17 coarsely noded radial ribs.

The present species, *C. (L.) latiaurata*, commonly known as "kelp-pecten", occurs at many places along the coast of southern California attached by its byssus to vegetable growths, pilings, or rocks. It occurs in shallow water but it has been taken at a depth of 229 meters (125 fathoms). Coe (413) discussed the growth and reproduction of this species. It reaches maturity in about 9 to 12 months and in that period of time attains a length of about 32 mm.

Formerly it flourished in the still, warm waters of Mission Bay (414), San Diego Co., where it lived attached to *Zostera*.

SUBGENUS SWIFTOPECTEN HERTLEIN

Swiftopecten Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 21, No. 25, p. 319, September 26, 1935. "the type of which is *P. swiftii* Bernardi." — Hertlein, Nautilus, Vol. 50, No. 1, p. 24, July 14, 1936. "Type: *Pecten swiftii* Bernardi."

Type species (by original designation.) — *Pecten swiftii* Bernardi [Journ. de Conchyl., Vol. 7, p. 90, pl. 1, fig. 1; pl. 2, fig. 1, July, 1858. "Hab. la baie Nicolas, dans la Manche de Tartarie." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, pl. 10, figs. 1a, 1b, 1931. (Reproduction of original figures of Bernardi.) — Masuda, Trans. Proc. Palaeo. Soc. Japan, N. S., No. 34, pp. 86-96, pl. 9, 1959.]

Range. — Late Miocene (Stanton) to middle Pliocene in California; mid-Miocene to Pleistocene in Alaska; early Miocene to Recent in Japan. Recent in from 1 to 143 meters (1 to 78 fathoms).

Description. — Shell of medium size, higher than long, nearly equivalve, ears well developed, the right the larger and with a deep byssal sinus and a ctenolium; right valve sculptured with 4 or 5, or occasionally more, large, coarse, rounded radial ribs (paired in some species), formed by corrugations of the shell, the left valve similar but with smaller ribs; valves usually with concentric undulations which form node-like areas on the ribs of the left valve; entire surface of valves and ears ornamented with rather coarse radial riblets, and the exterior surface superficially microscopically tessellated; hinge of right valve with an elevated ridge on each side of the ligamentary pit and fitting into two corresponding grooves in the hinge of the left valve; margin reflects the major exterior sculpture.

Remarks. — The members of *Swiftopecten* all have valves of nearly equal convexity, the left more so, and are chlamydoid in shape. The few coarse ribs where crossed by concentric undulations are thickened and give rise to node-like ornamentation. The character of the hinge with the two ridges, one on each side of the ligamentary

pit on the right valve and corresponding depressions on the left, bring to mind the observations of Beyrich and Futterer concerning correlation of the ribbing and the hinge of *Neithea*. Futterer (415) stated that "Hand in Hand mit dem Vorhandensein dieser 2 Zähne geht die Ausbildung eines 6-strahligen Baues in der Schale sculptur."

Concentric undulations somewhat similar to those on *Swiftopecten* occasionally occur on some species of *Lyropecten* such as those on *Chlamys* (*Lyropecten*) *crasscardo* and on *C. (L.) estrellana* and those on the Floridan *C. condylomata* Dall, an east American Miocene species. Node-like sculpture somewhat similar to that on *Swiftopecten* also is present on species of *Nodipecten* such as on *C. (N.) nodosa* Linnaeus, *C. (N.) subnodosa* Sowerby and *C. (N.) nodulifera* Sowerby.

Typical members of *Swiftopecten* made their first appearance in Japan in early Miocene and in western North America in strata of middle Miocene age in southeastern Alaska. In California this group of scallops first appear in beds of late Miocene age (Castaic Formation). Individuals occur abundantly in beds of middle Pliocene age in Lituya Bay in southeastern Alaska, in California from Crescent City to San Diego, and in Lower California on Pliocene terraces east of San Quintín, and at Bahía Tórtolo (Turtle Bay). A species of Pleistocene age, *C. (S.) kindlei* Dall, occurs in terrace deposits east of Nome, Alaska.

A species known to occur in beds of Miocene age in California, believed by some authors to bear relationship to members of the *Swiftopecten* group is the form described by Arnold as *Pecten* (*Chlamys*) *hamlini* (416). The type, a right valve, is, as mentioned by Arnold, a distorted specimen. We have examined a cast of the type specimen. It possesses 4 broad ribs each of which are radially grooved forming 5 radiating ridges. This rare species may be related to the *Swiftopecten* group or it may be referable to some other group with radially grooved ribs. Species such as *Pecten praevaselli* de Böckh and Richardson (417) in Douglas, a Persian species, have somewhat similar ribbing though no real relationship to such species is here suggested. The relationship, if any, of *P. hamlini* with other Californian species is not known at the present time.

The specimen of late Miocene age from California illustrated by Adegoke (Veliger, Vol. 9, No. 3, pp. 337-339, pl. 47, figs. 1 and 2, 1967) under the name of "*Swiftopecten* spec.", appears to be a juvenile *Lyropecten*.

Several species and subspecies of *Swiftopecten* have been described from Japan, Kamtschatka, and western North America. This group had its origin in the northern Pacific where the greatest number of extinct forms have been described and where the single Recent species, *C. (S.) swiftii*, has been recorded as occurring from late early Miocene to Recent in Japan.

Matsumoto suggested that the Miocene species described by him as *Pecten natoriensis* (418) is an ancestral form of *C. (S.) cosibensis* Yokoyama. Hatai and Nisiyama (419) in 1935 discussed the relationship of *C. (S.) cosibensis* Yokoyama, *C. (S.) heteroglypta* Yokoyama and *C. (S.) swiftii*. They believed, correctly we think, that the two former forms are distinct from *C. swiftii* and its American relatives with whose synonymy they were involved by Grant and Gale. Later Hatai and Nisiyama (420) called attention to the similarity of *C. natoriensis* and the form described by Arnold as *Pecten* (*Chlamys*) *nutteri*.

The shells of *C. (S.) cosibensis* and *C. (S.) heteroglypta*, especially during their earlier geological occurrences, are smaller than *C. (S.) swiftii*. Furthermore they have more ribs which are more nearly equal in size than those of *C. (S.) swiftii*. These facts together with the observation of Hatai and Nisiyama that in their early stages these species reveal a tendency to be more circular in outline, all point toward a specialized development from a chlamyd form. More recently Masuda (1962) referred *C. cosibensis* and *C. heteroglypta* to *Chlamys* s. s., an assignment not convincing to us.

Hatai and Masuda described a genus, *Nanaochlamys* (421), based upon *Pecten notoensis* Yokoyama. In the synonymy of this species they placed the forms named by Matsumoto as *Pecten natoriensis*, *P. n. subovalis*, and *P. n. inequilateralis*. The shell characters of their new genus were compared with those of *Mesopeplum* Iredale and *Scaeoichlamys* Iredale. Later Masuda (1962, p. 196) stated that *Nanaochlamys* is closely related to *Swiftopecten* but differing in "its orbicular symmetrical shell, surface sculpture, shape of auricles and indistinct ctenolium." He gave the range of *Nanaochlamys* as late Oligocene to Miocene.

Some authors have considered the type species of *Nanaochlamys* to be an ancestral member of the *Swiftopecten* group. If subsequent studies confirm this relationship, then *Nanaochlamys* would have little significance as a supraspecific taxonomic unit. According to MacNeil (U. S. G. S., Prof. Paper 553, p. 11, 1967), the left valve of *N. notoensis* is flat or slightly concave in the juvenile stage and this he believes is evidence opposed to close relationship to *Swiftopecten*.

The line of development indicated by members of *Swiftopecten* is quite distinct from that of *Decatopecten*, *Manupecten* and *Semipallium*, with which, at times, members of *Swiftopecten* have been placed. These subgenera include shells which are sculptured with a few coarse radially striated ribs.

Decatopecten Rüppel in Sowerby (422), type *Pecten plica* Linnaeus, includes shells of medium small size of which the right valve is a little more convex than the left, the hinge is short, byssal sinus very slight, and the hinge armature consists of perpendicular tooth-like plaits.

This subgenus occurs from Pliocene to Recent in the north Pacific, East Indies, and Red Sea region, in the post-Pliocene of east Africa and Recent from Japan to the Red Sea.

Anguipecten Dall, Bartsch, and Rehder (423), has hinge characters similar to those of *Decatopecten*, but the hinge line is shorter and the external sculpture consists of many nearly equal, rounded, radial ribs. It is represented in the Miocene of New Caledonia and Recent in Hawaii, Japan and the western Pacific.

Manupecten Monterosato (424), type *Pecten pesfelis* Linnaeus, occurs from mid-Miocene to Recent in the Mediterranean region and in Miocene and Pliocene strata in the Red Sea region. It lacks concentric undulations of the shell as well as a low ridge on each side of the ligamental pit of the right valve such as occur on *Swiftopecten*. In the character of the hinge and in some details of the sculpture *Manupecten* bears a closer resemblance to *Chlamys* than it does to *Swiftopecten*. *Felipes* Locard in Carus (425), is a synonym of *Manupecten* as it has the same type species.

Semipallium Jousseume (426), type *Pecten tigris* Lamarck, bears a close resemblance to *Manupecten*, but in the former group the left valve is generally consistently flatter than the right one. This character as well as the lack of concentric undulations on the left valve and the smaller size, easily serve to separate the members of this group from those of *Swiftopecten*. *Semipallium* occurs in the northern and western Pacific and Indian Ocean region. It is known to range from Miocene to Recent.

It is obvious that *Swiftopecten* is not closely allied to these groups nor to others which resemble it only in that they possess a few coarse radial ribs, such as *Mesopeplum* Iredale (427), *Nolochlamys* Cotton (428), *Anatipecten* Hertlein (429), and *Stralopecten* Rowland (430).

Chlamys (Swiftopecten) parmeleei Dall
Plate 31, Figure 5; Plate 37, Figures 1-10
Text Figure 10

Pecten (Chlamys) parmeleei Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 708, pl. 37, figs. 14, 14a, April, 1898. "Pliocene of San Diego, California; Parmelee." — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. 53, Pt. 1, p. 490, 1905. Original locality cited. — Arnold, U. S. G. S., Prof. Paper 47, pp. 28, 100, 119, pl. 41, figs. 1, 1a (copies of original figures), "San Diego formation (Pliocene, Pacific Beach, San Diego County, Cal.)", figs. 5, 5a ("Pliocene, Crescent City, Del Norte County, Cal."), 1906. — Arnold, in Eldridge, U. S. G. S., Bull. 309, p. 244, pl. 36, fig. 7, 1907. Type specimen illustrated and type locality cited. Also Pliocene of Puente Hills, southern California. — Keen and Benton, Geol. Soc. Amer., Spec. Papers No. 56, p. 92, 1944. Earlier records cited.

Pecten parmeleei Dall, Dall in Diller, U. S. G. S., Bull. 196, 1902. P. 32, wharf at Crescent City, p. 39, "same age as that at San Diego." Pliocene. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, pp. 150, 151, 1919 (as *Pecten parmeleei*). "San Diego," Pliocene. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 85, 1929. "Pliocene" "San Diego fauna." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 172. "Pliocene of San Diego."

Pecten (Pallium) swiftii Bernardi form *parmeleei* Dall, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 900, pl. 10, figs. 2, 5 (Holser Canyon, Los Angeles Co., Calif., Pliocene), 1931.

Pecten (Swiftopecten) parmeleei Dall, Hertlein and Grant, Calif. Jour. Min. Geol., Rept. 35, Calif. State Mineral., p. 69, 1939. "south slope of Soledad Mountain the San Diego formation." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, p. 56, "Pliocene strata at Pacific Beach," p. 57, "south sloping spurs of Mount Soledad," p. 59, "near the Mexican Boundary about three-quarters of a mile from the sea," 1944. — Hertlein and Grant, Calif. State Div. Min., Bull. 170, Chapter II, p. 60, 1954. "San Diego formation." "middle Pliocene or early upper Pliocene age."

Chlamys parmeleei Dall, Stewart, in Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, p. 91, 1941. Pliocene at San Diego. — Woodring in Woodring and Bramlette, U. S. G. S., Prof. Paper 222, pp. 65, 83, 103 (Jacalitos and upper part of San Joaquin), 104

(Pacific Beach and inland, San Diego, Calif., Pliocene), 106, pl. 16, fig. 20 (Fugler Point, Santa Maria district, Calif., Pliocene), 1950. — Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. "San Diego formation." Also Niguel Formation and others.

Chlamys ethegoi parmeleei Dall, Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, 1941. Pacific Beach, San Diego.

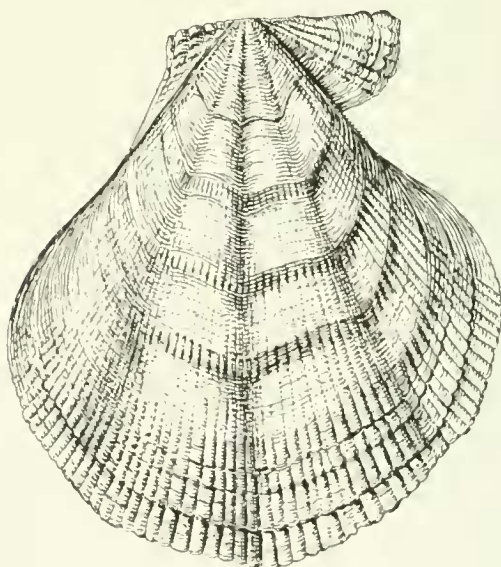
Type specimen. — Holotype, No. 154,479 United States National Museum.

Type locality. — "Pliocene of San Diego, California."

Range. — Late Miocene (Stanton); middle Pliocene, from southeastern Alaska to Bahía Tórtolo (Turtle Bay), Lower California.

Occurrence in San Diego Fm. — C.A.S. 957, 1401, 1413, 12147. L.A.M. 107, 116, 305, 305A, 318. Strata exposed in 1600 block, Larwood drive and Veya Court, Encanto. S.D. 38, 80, 408, 2916, 4735. Redwood Street and Swift Canyon. U.C. A-8333. U.C.L.A. 294.

Original description. — This species is close to *P. Swiftii* Bernhardt of Japan (J. de Conchyl., vii., plates 1 and 2, 1858) but smaller, and differs by the smooth top surface of the ribs, which in *P. Swiftii* are more or less striated or coarsely threaded, and by the not alternated radial riblets on the right posterior ear; also, especially, by the profuse coalescent microscopically checkered squamation, which makes a complete external coating to the valve. Alt. 45, lat. 38 mm. (Dall.)



Text Fig. 10. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Cat. No. 4735, San Diego Society of Natural History), right valve, from India and Spruce streets, San Diego; Pliocene. Length 6.18 mm. (Drawn by E. H. Quayle.)

Remarks. — About 150 specimens of *Chlamys (Swiftopecten) parmeleei* are present in collections observed by us from the San Diego Formation from the south slope of Mount Soledad, Pacific Beach, in San Diego, and near the Mexican boundary. Most of these are single

valves, the left more convex than the right, many in excellent state of preservation. The largest specimen in the collections of the San Diego Society of Natural History is a right valve, Cat. No. 2916 (SD), from Reynard Way (the anterior dorsal portion imperfect), 73.5 mm long, 75 mm high, convexity 18 mm. Another well preserved right valve, Cat. No. 4735 (SD), from India Street near Spruce Street in San Diego, is 65 mm long, 71.6 mm high, convexity 13 mm.

A fine series comprising most of the specimens of *C. parmeleei* studied by us was collected by G. P. Kanakoff at Locs. 305 and 305A (LAM) near the Mexican boundary. Individuals of various sizes, from 4 to 79 mm high, were present. Some attain a height of 32 mm with only a trace of undulation of the shell. Some have three, others as many as five, constrictions in the shell. These undulations, where they cross the ribs, lend a nodose appearance to the ribs.

The ribs are large, convex and consist of folds in the shell, those of the right valve corresponding to the interspaces of the left. There are four broad ribs on the right valve and often in addition a narrow, minor one near the anterior and posterior margins. The ribs on this valve are separated by narrower interspaces than those on the left. There are five ribs on the left valve which is more convex than the right. The ribs and interspaces of both valves are sculptured with nearly equal, coarse, radial threads. The anterior ears are much larger than the posterior ones and are sculptured with 5 to 9 riblets, those on the left posterior ear are fine and nearly equal in size.

Chlamys parmeleei described by Dall in 1898 was the first representative of the *Swiftopecten* group to be described from western North America. West American species which generally have been considered to be relatives of *C. (S.) parmeleei* were originally described in the following chronological order: *Pecten etcheogoini* Anderson (431), *Pecten (Chlamys) hamlini* Arnold (432), *Pecten (Chlamys) nutteri* Arnold (433), *Pecten (Chlamys) watti* Arnold (434), *Pecten (Chlamys) watti* var. *morani* Arnold (435), and *Pecten (Chlamys) kindlei* Dall (436). *Chlamys (Swiftopecten) donmilleri* MacNeil (437) was described recently from the Yakataga Formation of probable middle Miocene age in southeastern Alaska. The illustrations closely resemble some specimens of *C. (S.) parmeleei* but the Alaskan species was said to be comparable to the species described as *Pecten (Swiftopecten) otutumiensis* Nomura and Hatai from the Otsutsumi Formation of middle Miocene age in Japan.

There is considerable variation in the size and sculpture of the various forms of *Swiftopecten* of Pliocene age in California. Arnold (438) later recognized the identity of the form described as "*Pecten (Chlamys) watti* var. *morani*" with *Pecten etcheogoini*. He pointed out that *C. (S.) etcheogoini* is characterized by a lack of concentric constrictions whereas such constrictions were described as common on typical *C. (S.) watti*. We have examined fragments of the type specimen of *C. (S.) etcheogoini* which were recovered by F. M. Anderson from among the ashes caused by fire resulting from the earthquake in 1906. These fragments are the remains of a right valve which is No. 55 in the type series in the department of Geology, California Academy of Sciences. The largest fragment is 59 mm high and 42 mm long. It agrees exactly with the corresponding portion of the original

illustration of that species. The specimen shows no concentric undulations and it is quite deeply radially grooved. The latter character, however, may be accentuated due to erosion and fire.

Nomland (439) illustrated a number of specimens from the Etcheogoin Pliocene of the San Joaquin Valley and concluded that the species described as *Pecten watti* and *P. nutteri* both intergrade with *C. etcheogoini*.

Grant and Gale, 1931, placed *C. (S.) parmeleei* in the synonymy of *C. (S.) swiftii* and *C. (S.) etcheogoini*, *nutteri* and *kindlei* as varieties of *C. (S.) swiftii*. They believed that *C. (S.) etcheogoini* was a stunted form bearing very coarse striations on the ribs.

Stewart in 1941 studied fossil specimens from San Joaquin Valley and concluded (correctly, we believe) that west American forms of this group are probably more closely related to *C. (S.) parmeleei* than to *C. (S.) swiftii* although he recognized their similarity to the Recent Japanese species. He believed that *C. (S.) parmeleei* with prominent undulations is probably the same species as *C. (S.) watti* Arnold, differing in this character from *C. (S.) etcheogoini*.

Woodring (in Woodring and Bramlette, 1950), recently inferred from a study of specimens from Pliocene beds in the Santa Maria district, that there were two recognizable forms in that area, *C. (S.) parmeleei* in the Cebada Member of the Careaga Sandstone and *C. (S.) parmeleei etcheogoini* in the Foxen Mudstone.

Stewart mentioned that the ears of *C. (S.) etcheogoini*, especially on the left valve, are set off by furrows from the disk, differing in this respect from *C. (S.) swiftii*. Woodring (1950) also recognized this difference and mentioned that the dorsal umbonal portion of large specimens of *C. (S.) parmeleei* is more inflated than the corresponding portion on *C. (S.) swiftii*. However, these characters vary in a series of specimens.

Pecten etcheogoini Anderson was reported by B. L. Clark (440) from Pliocene terraces east of San Quintín Bay, Lower California. Recently Edwin C. Allison (441) collected a few right valves, the largest, 80 mm in altitude, from a terrace at the top of the mesa east of San Quintín Bay. The southernmost occurrence of *Swiftopecten* reported from the west coast of North America, is at Bahía Tórtolo (Turtle Bay), Lower California, where Allison collected a left valve at Loc. B-3019 (UC). The right valves from east of San Quintín almost lack concentric undulations and are deeply grooved. Based upon this character, these fossils could well be identified with *C. (S.) etcheogoini*. A portion of a valve similar to these was collected by Henry Hemphill at Pacific Beach, differing only in that it is gently undulated. Traces of microscopic squamation, believed by Dall to be characteristic of *C. (S.) parmeleei*, also are present on the valves from Lower California. Such ornamentation, however, also is present on specimens of *C. (S.) swiftii*. The specimens illustrated by Slodkewitsch (442) as representing *C. (S.) etcheogoini* from strata of Pliocene age in Kamtschatka, all show concentric undulations and are probably referable to some other species.

We have not made an intensive study of the members of this group described from the San Joaquin Valley, but *C. (S.) parmeleei* is the earliest name applied to a member of this group in North America and any subspecies or variety of later date must assume a subspecific

or varietal status of *C. (S.) parmeleei*, a fact not recognized by some of the earlier authors. We consider *C. (S.) parmeleei* to be a valid species (including *C. watti* as a synonym) with *C. (S.) etchegoini* (including *C. morani* as a synonym) as a subspecies and *C. (S.) nuttalli* a separate species.

The Alaskan form *C. (S.) kindlei*, said to be characterized by its large size and low convexity, resembles *C. (S.) swiftii* in general characters and especially in the shape and size of the posterior ears. We have examined single valves from Loc. 483 (CAS), from a depth of seventy feet on a terrace near Nome, Alaska.

A comparison of large specimens of *Chlamys (Swiftopecten) parmeleei* with *C. (S.) swiftii* from Japan reveals that on *C. (S.) parmeleei* and its subspecies the left posterior ear is generally sculptured with finer more nearly equal riblets. The radial threads on both valves of the Japanese shell tend to bifurcate toward the ventral margin whereas those on *C. (S.) parmeleei* only rarely show this feature. Furthermore the west American forms do not reach the size of *C. (S.) swiftii* which attains a height of at least 108 mm.

There is variation in the development of undulations of the valves in a series of *C. (S.) swiftii* but apparently all show in some degree undulations or constrictions in the growth of the shell. Masuda (1959), in discussing the variation of the shells of *C. (S.) swiftii*, mentioned that the valves are less convex and the constrictions less developed on individuals from northern Asiatic waters. He suggested that these features may be influenced by the smaller range in the annual water temperature in northern waters because greater variation occurs in shells which occur in more southern waters where there is greater range in the annual water temperature.

In addition to the occurrence of *Chlamys parmeleei* in the San Diego Formation, it has been reported from the Yakataga beds in southeastern Alaska; Crescent City, northern California; Purisima Formation (443); Jacalitos Formation and San Joaquin Formation in San Joaquin Valley; Cebada Member of the Careaga Sandstone, Santa Maria district; eastern Ventura basin; Simi Valley; in Elsmere, Holser and Temescal canyons and in the Puente Hills, southern California. Stanton (Jour. Paleol., Vol. 40, No. 1, pp. 23, 27, 1966) reported this species from the Castaic Formation of late Miocene age. We have not seen specimens from that area.

Chlamys (Swiftopecten) swiftii, a relative of *C. (S.) parmeleei*, lives in the waters about Japan, on the Pacific Ocean side from 38° to 51° north Latitude and on the Japan Sea side as far south as 35°, at depths of 1 to 143 meters (1 to 78 fathoms).

SUBGENUS *LYROPECTEN* CONRAD

Lyropecten Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 14, p. 291, August 1, 1862. Species cited: "*Lyropectin (Paltium) estrellanus*, C., Pacific R. R. Rept., 1855, vi. pl. 3, f. 15."; "*Paltium estrellanum*, in Pacific Railroad Reports, vol. vii. 191, . . . I propose to name it *Volaeformis*"; and "*L. crasscardo*." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, pp. 695, 701, 1898. "Type *P. estrellanus* Conr." — Arnold, U. S. G. S., Prof. Paper 47, p. 49, 1906. "Type *P. estrellanus* Conrad." — Woodring, U. S. G. S., Prof.

Paper 190, p. 34, 1938. Type as designated by Dall, 1898.

Lyropectin Conrad (err.), Proc. Acad. Nat. Sci. Philadelphia, Vol. 14, p. 291, 1862.

Lyropecten Conrad (emend. or err.), Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 105, 1869.

Not *Lyropecten* Hall in A. S. Miller, 1877. Type: *Avicula orbiculata* Hall. Middle Devonian.

Type species (designated by Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, pp. 695, 701, 1898). — "Type *P. estrellanus* Conrad." [Described as *Paltium estrellanum* Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 8, No. 6, p. 313, December, 1856 [apparently issued early in 1857]. "Locality. Estrella valley, Cal." — Conrad, Pac. Railroad Expl., Vol. 6, Pt. 2, p. 71, pl. 3, fig. 15, 1856 (1857). "Estrella Valley, Cal." Lectotype designated by Woodring (1938, p. 33) as the specimen illustrated by Arnold (U. S. G. S., Prof. Paper 47, pl. 20, fig. 1, 1906) which was from "Santa Margarita formation (upper Miocene), Estrella valley, San Luis Obispo County, Cal." This same specimen was designated as neoholotype by Tucker-Rowland (Mém. Mus. Roy. Hist. Nat. Belgique, Deuxième Sér., Fasc. 13, p. 4, July 31, 1938).]

Range. — Early Miocene (Vaqueros Formation) to middle Pliocene.

Description. — Shell large, thick, valves usually nearly equally inflated, sometimes undulated in the vicinity of the umbos, sometimes strongly constricted at various stages of growth; ears nearly equal in size, a byssal notch present under right anterior ear; ribs large and undivided; entire shell covered with radial striae and fine concentric imbrications; hinge with large coarse cardinal crura or teeth.

Remarks. — *Lyropecten* was represented during late Tertiary time in western North America by about a dozen species and subspecies. Various authors have speculated on the origin of this group with varying conclusions. J. P. Smith (444) suggested a Caribbean origin for the group. Woodring (1938, p. 35) stated that this subgenus may occur in beds correlated with the Chipola Formation in Florida of early Miocene age and that it is definitely represented in the Calvert Formation in Maryland, in beds of approximately middle Miocene age, but that no species of *Lyropecten* are known in the Tertiary strata in the Caribbean region or in Central America. Olsson (445) described one species referred to *Lyropecten* from beds of late Miocene age in Peru, but we have not seen specimens. An interesting occurrence is that of a large broad-ribbed species cited as *Pecten (Lyropecten) magnolia* Conrad by Haas (446), but probably referable to the *Pecten jeffersonius* group, from beds of Miocene age at Carballo, Costa Rica.

The assignment of large east American late Tertiary species to *Lyropecten* has been an accepted practice by Dall, Gardner, Mansfield, Tucker-Rowland, Woodring, Grant and Gale, and others. Certainly some of the species from the east and west American Tertiary beds are remarkably similar. However, most of the east American species lack the coarse hinge teeth which are so prominent on *Lyropecten*. Dollfus (447) long ago pointed out the similarity between some of the west American and Tertiary European species. Later Grant and Gale, and Clark and Durham (448), mentioned some of the same "analogous" species.

It is an interesting fact that Conrad who was familiar with east American species stated concerning *Lyropecten*, "This genus is peculiar to the Miocene of the Pacific slope . . ."

Most of the European authors while recognizing the similarity of some of the large European species with some of the American Tertiary fossils have hesitated to assign their species to *Lyropecten*. Roger (1939, p. 246), who made a careful study of the European Cenozoic Pectinidae, considered *Pecten madisonius* Conrad to be a *Chlamys* distinct from *Lyropecten*. North (449) who studied the supraspecific units of the Pectinidae also stated that in his opinion the large east American species are large chlamyds unrelated to *Lyropecten*. These two authors, who are familiar with European species, restrict the usage of *Lyropecten* solely to west American late Tertiary species.

The only east American species which we have seen whose sculpture and hinge bear a resemblance to those of *Lyropecten* was described as *Pecten (Nodipecten) condylomatus* Dall from the early Miocene of Florida. Some slightly nodose specimens of this species are very similar to the species described as *Pecten (Lyropecten) pretiosus* Hertlein from strata of early Miocene age in Baja California. A series of specimens of *C. condylomatus* was collected by T. F. Stipp from the type San Fernando Formation (of Dumble, 1915) in Tamaulipas, Mexico. Some of these, 70 mm high (considerably larger than the type specimen) and nearly devoid of nodes, closely resemble some specimens of *C. (L.) miguclensis submiguclensis* Loel and Corey of comparable size from the early Miocene of California.

The similarity of *Pecten magnolia* Conrad and *P. jeffersonianus* Conrad to European species of *Macrochlamis* Sacco (450) (*Gigantopecten* Rovereto, 1898; *Grandipecten* Cossmann and Peyrot, 1914), type, *Pecten latissimus* Brocchi, has been mentioned by several authors. It seems possible that they may be of related stock because there is reason to believe that conditions existed which were favorable to migration of marine organisms between the Mediterranean and the western Atlantic. This hypothesis is strengthened by the presence of another Tethyan subgenus, *Amussipecten*, which occurs in mid-Tertiary beds in the Caribbean (451) region and which is represented in the west American early Miocene strata by *Pecten vanblecki* Arnold. *Amussipecten* also is present in strata of Miocene age in the East Indies and in beds of Miocene and of Pliocene age in Japan, but there is no evidence to indicate that this subgenus reached western North America by way of the North Pacific. *Lyropecten* is not known to occur in that region.

Nodipecten Dall (452) with the type *Pecten nodosus* Linnaeus, includes a group of species somewhat similar in general characters to those of *Lyropecten*. They have broad, usually undivided ribs, rather few in number, ornamented with hollow nodes, and the entire valves are sculptured with fine or rather coarse radial threads. The posterior ear is often smaller than the anterior one; hinge characters similar to those of *Lyropecten*.

Some species of Pectinidae belonging to quite different groups bear nodes on their valves, especially on the ribs where valves are constricted or undulated. Two such species in the later Tertiary beds of Europe, *P. melii* Ugolini and *P. sardoa* Ugolini, were referred to the

"Groupe de *Chlamys nodosa*" by Roger (453). He placed (1939, p. 37) *Pecten nodosiformis* de Serres in the *Chlamys tournali* group which he indicated was referable to "*Macrochlamys*" of Sacco. Eames and Cox (454) placed that species in the subgenus *Gigantopecten* under the genus *Pecten*. Roger considered *Nodipecten* to differ from *Gigantopecten* [= *Macrochlamis* Sacco] in the smaller apical angle, the more unequal ears and better developed byssal sinus. He stated that only the presence of nodes creates a similar appearance between the two groups. The *Nodipecten* group is known to range from Miocene to Recent in the Caribbean region and from Pliocene to Recent in the west American Cenozoic.

Some of the shell characters mentioned by authors upon which *Lyropecten*, *Macrochlamis*, and *Nodipecten* have been separated are the difference in the convexity of the two valves, the presence or lack of a ctenolium (pectinidial teeth), the apical angle, and presence or absence of nodes. All these shell characters are variable and occur in various species assigned to these different groups.

The type species of *Lyropecten* is a west American Miocene species and this group is well developed in that region from early Miocene to middle Pliocene. *Lyropecten*, throughout its history, appears to have been restricted to the eastern Pacific. The latest species, *C. (L.) cerrosensis*, occurs in strata of Pliocene age in southern California and in Lower California. Grant and Gale (455) assigned *Pecten magnificus* Sowerby, a Recent tropical west American species, to *Lyropecten*, but it is more properly placed in *Nodipecten*.

The recent species of *Nodipecten* are inhabitants of tropical and subtropical waters. *Chlamys (Nodipecten) subnodosus* var. *intermedius* Conrad, ranges north at least to Los Angeles Bay in the Gulf of California (perhaps farther) and to Scammon Lagoon on the west coast of Lower California (456). *Lyropecten* also appears to have been an inhabitant of waters, perhaps subtropical rather than tropical.

Athlopecten Marwick (457), type *Pecten athleta* Zittel, from beds of early Miocene or late Oligocene age in New Zealand, includes species with large coarse shells with undivided ribs. There is some resemblance to *Lyropecten* but any direct relationship has not been demonstrated. *Pecten athleta* bears a resemblance to *Pecten simpsoni* Philippi (458), from the middle Tertiary of Chile, but there is no evidence that either species is referable to *Lyropecten*.

Vertipecten Grant and Gale (1931, p. 188), type, *Pecten nevadanus* Conrad, has a large thick shell with irregular, often spiny ribs, and the hinge lacks teeth such as are present on *Lyropecten*. They compared *Vertipecten* to *Phialopecten* Marwick. We have examined specimens of the type species of *Phialopecten*, *P. triphooki* Zittel, which we received from Dr. C. A. Fleming, and any postulated relationship with *Vertipecten* appears purely speculative.

Sectipecten Marwick with broad ribs, late Miocene to middle Pliocene in New Zealand, is believed by Boreham (459) to have been derived from the *Mesopeplum* group.

Chlamys (Lyropecten) cerrosensis Gabb
Plate 34, Figures 1-4; Plate 36, Figure 7

- Pecten cerrosensis* Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 32, pl. 9, figs. 55, 55a, 1869. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 173, 1912. "San Diego-Purisima." — "Pliocene." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, pp. 150, 151, 1919. "San Diego." Pliocene. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, pp. 84, 85, 1929. "San Diego Pliocene." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 40, 1939. "San Diego horizon." — Hertlein and Grant, Calif. Jour. Min. Geol., Rept. 35 State Mineral., p. 69, 1939. "Pacific Beach" (p. 68), "Pliocene."
- Pecten (Lyropecten) ashleyi* Arnold, U. S. G. S., Prof. Paper 47, p. 122, pl. 47, figs. 1, 1a; pl. 48, fig. 1, 1906. "The type is from Cerros Island." Also, "in the low hills across the mesa three-fourths of a mile northeast of Pacific Beach, near San Diego." "Pliocene."
- Pecten ashleyi* [Arnold], J. P. Smith, Calif. State Min. Bur., Bull. No. 72, p. 38, November, 1916. "San Diego and Lower Fernando formations of the coastal region of southern California."
- Pecten (Plagiocentrum) cerrosensis* Gabb, Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 1, p. 15, pl. 6, fig. 1, 1925. (Illustration of Gabb's type specimen).
- Pecten (Lyropecten) cerrosensis* Gabb, E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 432, pl. 32, fig. 4 (Cedros Island), 1926. Also, "San Diego formation of southern California," Pliocene. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 57, 1944. "Pliocene strata at Pacific Beach" (p. 56). — Hertlein and Grant, Calif. State Div. Mines, Bull. No. 170, chapter 2, p. 60, 1954. "San Diego formation." Pliocene. — Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 44, pl. 20, figs. a, b, 1968. Chula Vista, Pliocene.
- Pecten (Lyropecten) estrellanus* (Conrad) variety *cerrosensis* Gabb, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 187, pl. 8, figs. 1a, 1b, 2a, 2b; pl. 9, fig. 2 (specimens illustrated from southern California), 1931. "San Diego (Dall and Stearns in Arnold)."
- Lyropecten cerrosensis* Gabb, Woodring, U. S. G. S., Prof. Paper 190, p. 32, pl. 7, figs. 1, 2 (specimens illustrated from Los Angeles), 1938. Arnold's record of *P. ashleyi* from northeast of Pacific Beach cited (p. 33). — Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, p. 113, 1940 (issued June 7, 1941). "Sea cliff at Pacific Beach." Pliocene. — Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 207, p. 85, pl. 21, fig. 1 (from Santa Maria district), 1950. P. 104, Pacific Beach; "(second bench back on mesa, 3/4 mile northeast of Pacific Beach)"; p. 106, "San Diego formation," "Pliocene." — Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. "San Diego formation," also Niguel Formation and others.
- Lyropecten (s. s.) estrellatus cerrosensis* Gabb, Glibert and Van de Poel, Mém. Inst. Roy. Sci. Nat. Belgique, Deuxième Sér., Fasc. 78, p. 24, 1965. Pacific Beach, San Diego Co., California, Pliocene.
- Type specimen. — No. 1091, University of California, Department of Paleontology.
- Type locality. — "Cerros Island, off the coast of Lower California: probably Miocene."
- Range. — Middle Pliocene of southern California (460) and northwestern Lower California and Cedros Island.
- Occurrence in San Diego Fm. — C.A.S. 547, 1179, 1413, 1414, 12142, 28159, 28894. L.A.M. 122, 305, 305C.
- Original description. — Shell equi-convex, subcircular, broader than long, convex; beaks small; sides sloping concavely above, rounded below; ears small, subequal, roughened and irregular, sinus very small. Surface marked by eighteen or twenty flat ribs, with flat or slightly concave interspaces; margins undulated, the ends of the ribs being deeply emarginated, and the interspaces being prolonged into tongue-like processes. (Gabb.)
- Remarks. — The type specimen of this species was discussed and illustrated by the senior author, 1925. The dimensions of the type are, height, 210 mm, length, 220 mm, convexity (both valves together), 90 mm, umbonal angle, approximately 110°. The entire shell is radially striated with fine threads as are other species of *Lyropecten*. The interspaces bear four or five striations or threads of which the central one is stronger than the others and forms a midrib. As pointed out in earlier discussions, the specimen referred by Arnold (1906, pl. 49, figs. 1, 1a, 1b) to *Pecten cerrosensis* is referable to other species and the species which he described under the name of *Pecten (Lyropecten) ashleyi* is now believed to be identical with Gabb's species.
- A large, well preserved specimen in the collections of the San Diego Society of Natural History, from Telegraph Canyon, near Chula Vista, is 193 mm long, 179 mm high, the convexity (both valves together) 88 mm. Most of the specimens of *C. (L.) cerrosensis* in collections from San Diego which we have examined are single valves and all except two from near the Mexican boundary are from or near Pacific Beach. A well preserved right valve, 146 mm long and 138 mm high, agrees in all details with specimens from southern California referred to *C. (L.) cerrosensis* (or *Pecten ashleyi*). It has 17 well developed and radially striated ribs. One of the threads in the center of the interspaces is coarser than the others and forms a midrib. Another right valve, from Loc. 1413 (CAS), has 18 radial ribs. Another specimen, the umbonal portion lacking, but apparently a right valve, has 19 radial ribs with the midrib in the interspaces only weakly developed. A right valve, 146 mm long and 138 mm high, from Loc. 305C (LAM), near the Mexican boundary, with 18 radial ribs and somewhat subdued radial striation, agrees in all particulars with specimens of *C. (L.) cerrosensis* from strata of Pliocene age on Cedros Island.
- The general characters of the shell of the present species closely resemble those of *C. (L.) estrellanus* (461), a species of late Miocene age. A midrib is present in the interspaces between the ribs of *C. (L.) cerrosensis* as it is in *C. (L.) estrellanus* and its subspecies. However, the midrib is usually decidedly finer than it is on the shells of of the *C. (L.) estrellanus* group. Some young specimens of *C. (L.) cerrosensis* have a well developed midrib and in this respect closely resemble some specimens of *C. (L.) estrellanus*. Compared to typical *C. (L.) estrellanus* Conrad (see Arnold, plate 20, fig. 1) the valves of *C. (L.) cerrosensis* are less inflated, generally larger, more elongated posteriorly, the midrib in the interspaces is usually smaller and not split at the margin, there are more numerous riblets on the ears and often there are more and coarser radial threads and riblets on the posterior

submargin. *Chlamys* (L.) *cerrosensis* has more numerous ribs which are usually more rounded than those on *C. (L.) estrellanus terminus* Arnold (462) which has but 15 flat-topped ribs. The valves of *C. (L.) cerrosensis* are more convex and the midribs are usually finer than are those of *C. (L.) estrellanus catalinae* Arnold (463). *Chlamys* (L.) *gallegosi* E. K. Jordan and Hertlein (464) bears a close resemblance to *C. (L.) cerrosensis* but the former species has flatter, squarer, and much more closely spaced ribs, the riblet in the interspaces is much coarser and the radial threads on the shell are generally coarser.

In general outline and sculpture *C. cerrosensis* bears a similarity to *C. (L.) crassicaudo* Conrad (465) but differs in possessing a midrib in the interspaces between the major ribs, in the usually greater number of ribs, 17 to 19 or 20 in comparison to 14 to 17, also in lacking constrictions which often are present on the shell of Conrad's species.

GENUS HINNITES DEFRANCE

Hinnites DeFrance, Diet. Sci. Nat., Vol. 21, p. 169, 1821.

Species cited, *Hinnites cortesy* DeFrance and *Hinnites dubuissoni* DeFrance. — Cossmann and Peyrot, Act. Soc. Linn. de Bordeaux, Vol. 68, p. 141 (Conch. Néog. de l'Aquitaine, Vol. 2, livr. 2, p. 341), 1914. "G.-T.: *Ostrea crispa* Broc.; = *Hinnites cortesii* Defr. Miocene et Pliocene." — Grau, Allan Hancock Pac. Exped., Vol. 23, p. 133, 1959. Type, *Ostrea crispa* Brocchi, 1814 = *Hinnites cortesy* DeFrance, 1821.

Hinnita Férussac and Deshayes, Tabl. Syst. Anim. Moll., Tabl. Syst. Généraux, p. XL, 1822. [No species mentioned.] Type designated by Gray (Ann. Philos., New Ser., Vol. 12, Art. 4, p. 103, August, 1826): *Lima gigantea* Gray.

Hinnita Gray, Ann. Philos., Vol. 10, New Ser., p. 104, August, 1826. Emendation of *Hinnites* DeFrance. "It [*H. gigantea*] may be considered as the recent type of that genus." On p. 362, November, 1826, "The name of this genus must be changed to *Hinnus*."

Type species (designated by Gray, Proc. Zool. Soc. London for 1847, p. 201). — "*H. Cortesy*" [= *Hinnites cortesy* DeFrance, Diet. Sci. Nat., Vol. 21, p. 169, Atlas, pl. 86, figs. 1, 1a, 1821 = *Ostrea crispa* Brocchi, Conch. Subappenn., Vol. 2, p. 567, 1814. "Fossile nel Piacentino," Italy. Illustrated by Roger, Mém. Soc. Géol. France, Nouv. Sér., Vol. 17, Fasc. 2-4, Feuilles 7-13, Mém. No. 40 (completion of Mém. de Paléo., No. 26), p. 172, pl. 23, figs. 11, 12; pl. 25, figs. 1-3 (figs. 1 and 3 "type de *H. cortesy*"); pl. 28, figs. 2, 1939 (as *Chlamys crispa*). "Pliocene inférieur du Plaisantin".]

Range. — Oligocene to Recent. Recent from low tide to 110 meters (60 fathoms).

Description. — Shell to an altitude of about 20 or 30 mm resembling *Chlamys*, then becoming sessile, the shell becomes irregular, thickened, and the resilial pit elongated.

Remarks. — The relationships of many members of this group of mollusks are not known with certainty. It is believed that some species of *Chlamys* become attached and assume a *Hinnites* form. Fisher (466) studied the anatomy of *Hinnites sinuosus* Gmelin (= *Pecten pusio* Linnaeus) and stated that no essential differences exist between the soft parts of that and other species of

Hinnites and those of *Pecten*. This lends credence to the view of various authors that the genus *Hinnites* is polyphyletic, including species of similar form but genetically not closely related. This view has been accepted by Dall (467) and others.

Prohinnites was proposed by Gillet (468) for Cretaceous species which she considered to bear no relationship with similar Tertiary forms. Species from Jurassic strata which Rollier (469) referred to *Hinnites* are now placed in different genera.

Despite the obvious differences in the genetic relationships of the species referred to *Hinnites*, the shell characters are so similar that for convenience it seems best to apply this generic name to the various Cenozoic species.

One species of *Hinnites* has been reported to range from early Miocene to Recent in California. Some authors consider the Miocene form to be separable as a subspecies. Finlay and Marwick mentioned that in New Zealand, *Hinnites* first appeared in beds of Awamoan, middle Miocene age.

Hinnites giganteus Gray Plate 41, Figure 16

Lima gigantea Gray, Ann. Philos., New Ser., Vol. 9, p. 139, 1825. [No locality cited.]

Not *Plagiostoma gigantea* J. Sowerby, Miner. Conch., Vol. 1, p. 176, pl. 177 (two figs.), 1814. "This species is found in great variety in the Bath Lias or Foetid Limestone." England, Jurassic. [Family Limidae.]

Ostrea gigantea [Gray] Wood, Index Test., Suppl., p. 7, pl. 2, *Ostrea*, fig. 7, 1828. Habitat unknown.

Hinnita poulsoni Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 1, p. 182, pl. 14, October, 1834. "The habitat is unknown to me" (Conrad.)

Not *Pecten poulsoni* Morton, Synopsis of the Organic Remains of the Cretaceous Group of the United States, p. 59, pl. 19, fig. 2, early in 1834.

Hinnites giganteus Gray, Sowerby, Thes. Conch., Vol. 1, p. 80, pl. 20, figs. 5-7, November 2, 1842. [No locality cited.] — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 63, pl. 25, figs. 1a, 1b, 1924. Aleutian Islands to Magdalena Bay, Lower California, Recent. Also cited from Pliocene and Pleistocene of California. — Adam, Bull. Inst. Roy. Sci. Nat. Belgique, Tom 36, No. 20, p. 1, footnote, pl. 2, figs. 3a, 3b, 1960. Balboa, California, Recent.

Pecten rubidus Hinds, varietas (?), Middendorff, Beiträge zu einer Malacozöologie Rossica, Mém. Sci. Nat. de l'Acad. Impér. des Sci. de St.-Petersbourg, Vol. 6, Pt. 3, p. 528 (separate Vol., p. 12) (in part), pl. 13, figs. 4, 5, 6, 1849. "die Insel Sitcha (Wosness)."

Not *Pecten rubidus* Hinds, 1845.

Pecten (Hinnites) giganteus Gray, Kobelt, Syst. Conchyl.-Cab. von Martini und Chemnitz, Bd. 7, Abt. 2, p. 252, Taf. 66, figs. 1-3, 1888. West coast of United States from California to Straits of Juan de Fuca, Recent. — Arnold, U. S. G. S., Prof. Paper 47, p. 93, pl. 29, figs. 1 (type of *H. crassa* Conrad), 2 (San Diego, Recent), 1906. P. 94, "Pliocene. Pacific Beach, San Diego (Arnold)."

Pecten (Chlamys) multirugosus Gale, Trans. San Diego Soc. Nat. Hist., Vol. 5, No. 9, p. 92, February 29, 1928.

Pecten (Pecten) multirugosus Gale, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 159, pl. 11, figs. 5a, 5b (San Pedro, Calif., Recent), 1931. P. 160, "Pacific Beach, San Diego (Arnold)."

Hinnites multirugosus Gale, Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull., No. 90, p. 41, fig. 7, 1953. "Queen Charlotte Islands, British Columbia, to Abrejos Point, Baja, California." — Grau, Allan Hancock Pac. Exped., Vol. 23, p. 134, pls. 45-49, 1959. Earlier records cited.

Type specimen. — In British Museum (Natural History) (A. M. Keen, written comm., February 8, 1967); of *Pecten (Chlamys) multirugosus* Gale, No. 5, San Diego Society of Natural History.

Type locality. — No locality originally cited. Of *Pecten (Chlamys) multirugosus* Gale, "The type is a Recent specimen from San Diego," California.

Range. — Early Miocene (Fritsche); middle Miocene (Temblor, "cf." [Loel and Corey]); late Miocene to Recent. Recent from the Aleutian Islands, Alaska, to Magdalena Bay, Lower California, Mexico, in sheltered waters from high tide to a depth of 55 meters (30 fathoms). In northern waters it lives close to shore and in shallower water (Fitch).

Occurrence in San Diego Fm. — L.A.M. 305, 309, Pacific Beach, at letter "h" in Pacific "Beach" Junior High School shown on U. S. G. S. topog. map, La Jolla quad.

Original description of *Lima gigantea* Gray, 1826. — "T. oblonga, extus pallide brunnea confertim radiat-sulcata, extus alba, margine cardinali purpurea: Long. 4, alt. 5 poll."

"Irregularly oval, thick, radiately striated, with the ears small, narrow, hinge thick; colour pale brown, with reddish radiating streaks, inside white, hinge purple." (Gray.) (Ann. Philos., New Ser., Vol. 12, p. 103, 1826.)

"The young of this species is a typical *Chlamys* up to the size of 20 or 30 mm. The left valve resembles closely the left valve of *Pecten hastatus* Sowerby, or the young of some specimens of *Pecten squamatus* Gmelin from Japan, being sculptured with small radiating ribs, every fourth or fifth raised above the others and covered with spines. It is about the shape of *P. squamatus* but is slightly more circular than *P. hastatus*. The right valve does not have the high paired ribs of *P. hastatus*, but has low ribs, flattened on top, nearly all the same size with only occasionally a slight accentuation of every third. As soon as the young *Chlamys* assumes a sessile position, the growth becomes very irregular, influenced considerably by the shape of the object to which it is attached, the ribs become coarser and spinose, and the shell thickens rapidly, oyster-like, especially the right (the lower) valve which may in the process develop a greatly elongated resilial pit." (For *Pecten (Chlamys) multirugosus* Gale, 1928.)

Remarks. — A left valve of this species, about 74.3 mm long and 84 mm high and 35.5 mm in convexity, was collected by G. P. Kanakoff at Loc. 305 (LAM) near the Mexican boundary. It is more convex than is usual for this species but otherwise it is similar to Recent specimens. A right valve, 73 mm long and 76 mm high was collected by J. F. Arndt near Pacific Beach Junior High School. A fragment, probably this species, was collected by Kanakoff at Loc. 309 (LAM).

The taxon "*Pecten (Chlamys) multirugosus*" was

proposed by Gale, 1928, to replace *Lima gigantea* Gray, 1825, because of the earlier *Plagiostoma gigantea* J. Sowerby, 1814. Gale considered *Plagiostoma* to be a subgenus of *Lima*, in which case Gray's species became a secondary homonym. *Plagiostoma* J. Sowerby (1814, p. 175) was originally described as a genus and it is so used by many modern authors. Under this usage the combination *Lima gigantea* Gray is not a homonym and the specific name "*giganteus*" is nomenclaturally valid in combination with the genus *Hinnites*. We favor retention of this well known combination of names believing that this lends stability to the nomenclature of this species. Adam (1960) recently maintained the validity of this taxon.

If the name *Hinnites giganteus* be abandoned the next available name is "*Hinnita*" *poulsoni* Conrad. This name is not a homonym of the earlier *Pecten poulsoni* Morton, as believed by Grant and Gale. The type locality of *H. poulsoni* Conrad is unknown but nearly all authors who have considered the taxonomic status of this species have placed it in the synonymy of *H. giganteus*.

Hinnites crassa Conrad (470), described from beds of late Miocene age in California was renamed *crassipliatus* by Gale (471) as a variety of the Recent form *multirugosus*. However, the name of Conrad's species is not preoccupied by *Pecten crassus* Risso, 1826, and no replacement is necessary. Gale believed the Miocene form to be smaller, usually with the *Chlamys* stage lasting longer, with less irregular growth and with fewer more highly differentiated coarse, rugose radial ridges. The taxonomic value of the name applied to this form is open to question. It may be a subspecies of the Recent form but Arnold (472) considered it to be identical with the Recent species and we are inclined to that view. Woodring and Stewart (473) reported "*Hinnites* cf. *H. crassa* Conrad" from the Etchegoin Formation, late Pliocene, in the San Joaquin Valley. *Hinnites benedicti* Adegoke (474), from the Santa Margarita Formation of late Miocene age, was described from the same region.

Dollfus and Dautzenberg (475) mentioned that a series of specimens of *Hinnites crassa* from late Tertiary beds in Europe reveals variations analogous to those of *H. giganteus*.

A paper by Yonge (476) contains the results of a study of the habits of Recent *H. "multirugosus"*. He stated that attachment to the substratum takes place when the shell is between 2.2 and 4.2 cm high.

This species attains a large size in northern waters. Eyerdam (477) mentioned a specimen from the San Juan Islands in Puget Sound which was 222 mm (8 3/4 inches) long, 168 mm (6 1/2 inches) wide, and near the byssal plug the valve was 64 mm (2 5/8 inches) thick. The lower valve weighed 3 pounds and 1 ounce. This species is gathered for food, only the large adductor muscle is eaten. A huge specimen 230 mm long, was reported by T. Meagher from Santa Cruz Island, California. (The Echo: Western Soc. Malacol., p. 38, 1968).

Henderson (478) pointed out that Bryan's (479) record of *H. giganteus* in Hawaii is referable to a species of *Spondylus*. Records of *H. giganteus* from the Coraline and the Red Crag in England were referred by Woods (480) to *H. cortesyi* DeFrance.

GENUS *CYCLOPECTEN* VERRILL

Cyclopecten Verrill, Trans. Connecticut Acad. Arts and Sci., Vol. 10, Pt. 1, p. 70, 1899 [issued June, 1897]. "Types, *Pecten pustulosus* Verrill; *P. imbrifer* Loven." — Marwick, Trans. New Zealand Inst., Vol. 59, Pt. 4, p. 909, 1929. "Type: *Cyclopecten postulosus* Verrill." — Grau, Allan Hancock Pac. Exped., Vol. 23, p. 21, 1959. "Type species: *Pecten pustulosus* Verrill, 1873." *Cyclopecten* (err.) de Gregorio, Ann. de Géol. et Paléo., Livr., 23, p. 43, 1928.

Cycloclamys Finlay, Trans. New Zealand Inst., Vol. 57, p. 452, issued separately, December 23, 1926. "I supply for it [*Pecten transenna* Suter, Man. New Zealand Moll., p. 881, pl. 52, fig. 3, 1913. "Near the snares, in 50 fathoms (type), New Zealand, Recent] the new generic name *Cycloclamys*." — Marwick, Trans. New Zealand Inst., Vol. 58, Pt. 4, p. 453, 1927, published separately February 28, 1928. [Use of *Cycloclamys* discussed.]

Not *Cyclopecten* Seguenza, Boll. Comit. Geol. Ital., Vol. 8, Nos. 9-10, p. 362, 1877. Sole species: *Cyclopecten peloritani* Seguenza, p. 362, 1877. Messina, Pliocene.

Type species (designated by Sykes, Smith, and Crick, Zool. Rec., Vol. 34, Moll., p. 75, 1898). — "type: *C. pustulosus*, Verrill" [= *Pecten pustulosus* Verrill, Amer. Jour. Sci., Ser. 3, Vol. 5, p. 14, January, 1873. "Near St. George's Bank (s), in 150 fathoms, mud (living); east of St. George's (g) in 430 fathoms, sand and gravel (dead, but fresh valves.)" off Newfoundland. — Verrill, 1897, p. 70, fig. 1 (as *Cyclopecten pustulosus*). — Verrill and Bush, Proc. U. S. Nat. Mus., Vol. 20, No. 1139, p. 839, pl. 85, figs. 5, 6, 10, 11, 1898 (as *Cyclopecten pustulosus*)].

Range. — Late Miocene to Recent. Recent, Atlantic; eastern Pacific; New Zealand region; in 5 to 2323 meters (3 to 1270 fathoms).

Original description: Shells thin, rounded, scarcely oblique, with symmetrical auricles and simple margins. The two valves are quite unlike in sculpture. The right valve is a little flattened and upturned at the flexible margin, so as to fit tightly against the upper valve. The thin lower valve has, in the typical species, regular, thin, elevated concentric lamellae, which aid in the adaptation of the edge to that of the upper valve; the margin is usually flattened or bevelled. The upper (left) valve is radially sculptured, rarely smooth; it usually has radial rows of arched scales, pustules, or points, and also concentric raised lines; it is sometimes cancellated. No radial ribs, nor interlocking points at the margin. Auricles well developed, subequal, angulated and well-defined at both ends; byssal notch well defined; few or no pectinidial teeth. Cardinal folds single, rather feebly developed, often cross-lined. Eyes few. Byssus small, and of few threads. (Verrill.)

Remarks. — Grau (1959, p. 22) mentioned that "Some species do not have the ventral margin of the right valve flexed, and one, *Cyclopecten acutus* sp. nov., does not have concentric lamellae or ridges on that valve. Most species are translucent but a few are opaque". He included twelve west American species in *Cyclopecten*.

The shells of species of *Cyclopecten* are prismatic in structure. Some of the species with flexed ventral margin of the right valve resemble some species of *Propeamusium* (481) but differ in lacking internal radial rays.

Chlamydella Iredale (482) differs from *Cyclopecten*

in the elongated (anterior-posterior) form and in that the right valve is sculptured with fine radial riblets separated by raised scales, the left with fine concentric raised threads.

Barnard (483) described *Cyclopecten incubans* from South Africa which contained juvenile forms. He pointed out that this apparently is the first reported occurrence of incubation in the Pectinidae.

Cyclopecten pernomus Hertlein
Plate 33, Figures 7, 11

Pecten (*Cyclopecten*) *rotundus* Dall, Bull. Mus. Comp. Zool. Harvard Coll., Vol. 43, No. 6, p. 404. "U. S. S. 'Albatross', station 2799, in Panama Bay, in 29 1/2 fathoms; also at station 2784, in 194 fathoms, mud, bottom temperature 51.9° F. U. S. N. Mus. 110, 708." Not *Pecten rotundus* von Hagenow, 1842, p. 554. Chalk on Rügen Island in Baltic Sea, Cretaceous.

Pecten (*Cyclopecten*) *pernomus* Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 21, No. 25, p. 320, pl. 18, figs. 11-13, September 26, 1935. Dall's localities cited, also others. A new name for *Pecten* (*Cyclopecten*) *rotundus* Dall, 1908, not *Pecten rotundus* von Hagenow, 1842.

Cyclopecten pernomus Hertlein, Grau, Allan Hancock Pac. Exped., Vol. 23, p. 32, pl. 11, September, 25, 1959. Numerous localities cited from western Lower California to Ecuador. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 72, fig. 135, 1958. Cedros Island, Lower California to Panama.

Amusium (*Cyclopecten*) *pernomus* Hertlein, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 168, pl. 21, fig. 6, 1961. Cedros Island, Lower California, to Panama, Recent.

Type specimen. — No. 110, 708, United States National Museum.

Type locality [of *Pecten* (*Cyclopecten*) *rotundus* Dall]. — "U. S. S. 'Albatross', station 2799, in Panama Bay in 29 1/2 fathoms."

Range. — Middle Pliocene to Recent. Recent from Cedros Island, west coast of Lower California, Mexico, and Angel de la Guardia Island in the Gulf of California, to La Libertad, Ecuador. Also Guadalupe Island and Galapagos Islands (Grau). In 2 to 1,720 meters (1 to 940 fathoms) (484). "Usually found in mud bottoms, occasionally sandy mud or sand; sometimes associated with eel grass or weed" (Grau).

Occurrence in San Diego Fm. — L.A.M. 305A, 305C.

Original description (of *Pecten* (*Cyclopecten*) *rotundus* Dall). — Shell very small, thin, white, suborbicular, with subequal ears, both valves nearly equally convex; right valve polished, minutely regularly concentrically striated, which sculpture is barely visible under a hand lens; posterior ear smooth, anterior finely radially threaded, with a narrow but clean-cut byssal sulcus and fasciole; left valve finely sharply radially striated, the anterior ear finely reticulated, the posterior apparently nearly smooth; hinge line short, straight; interior smooth, a pair of small auricular crura present; the hinge line with a minute central pit and two relatively large transversely sharply striated, elongate areas representing a permanent provinculum. Height and length, 3; hinge line 2.5; diameter, 1.0 mm. A single valve from near the Straits of Magellan, apparently

the same species, measures 7 mm in height. (Dall.)

Supplementary description. — The right valve is slightly smaller than the left. Its anterior auricle has concentric as well as radial striae; its posterior auricle is not "smooth", having 7 to 11 fairly prominent radial threads and finer concentric threads. The posterior auricle of the left valve is not "nearly smooth," having both fine radial and finer concentric threads. On about half of the hundreds of left valves examined there were gray-brown, yellow-brown, red-brown or deep brown areas, irregular and varying in size; the right valves were all white. Specimens measuring 10 mm in altitude were taken at Hancock station BS 2130, Pond Island, northern Gulf of California, in 62-85 fathoms; the largest specimens previously recorded were 7 mm in altitude. (Grau.)

Remarks. — Ten single valves varying in degree of preservation, are present in the collection of Los Angeles County Museum from Locs. 305A and 305C (LAM) from near the Mexican boundary. The largest is about 5.5 mm long. Some of them retain traces of the brownish color markings on the ventral portion of the shell.

These specimens agree in all shell characters with Recent specimens of *Cyclopecten pernomus* dredged in tropical west American waters. Gilbert Grau agrees with this assignment. This is the first record of the occurrence of this species in the fossil state.

Cyclopecten pernomus lacks the distinct posterior flexure which is present on the right valve of *C. cocosensis* Dall (485). The auricles of *C. pernomus* are much less acutely pointed than those of *C. acutus* Grau (486) from West Colombia and the left valve is sculptured with concentric ridges rather than with fine radial threads.

Grau (1959, p. 33) pointed out that the single valve from the Strait of Magellan which Dall believed to be probably referable to "*Pecten (Cyclopecten) rotundus*" [= *C. pernomus*] is not conclusive evidence that this species lives in those southern waters.

SUPERFAMILY LIMACEA RAFINESQUE FAMILY LIMIDAE RAFINESQUE (487)

Shell monomyarian or with a single adductor scar, obliquely subpectiniform with small, narrow ears and median beaks, equivalved, inequilateral, the shorter side being posterior, usually white, externally sculptured with fine or coarse, generally scabrous radial riblets. Lateral margins generally thickened, the anterior one with an open gap. Hinge line straight, edentulous, or with obscure denticulations on the side, the cardinal area high, subtriangular with a central resilial pit under the beak in each valve. A thin brown deciduous periostracum is often present. (Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca New York), p. 169, 1961.) Late Paleozoic (Carboniferous) to Recent.

Remarks. — The triangular ligamental pit in this family is external, rather than internal, and the position of the adductor impression is higher and more posteriorly situated than it is in the Pectinidae. A byssus may be present or lacking, but if present it extends through a slight gape in the valves. Some members lacking a byssus are active swimmers.

Early members of this family, so abundant and large in the Mesozoic Era, were discussed by Cox (488).

GENUS *LIMA* BRUGUIÈRE

Lima Bruguière, Encyl. Méth. (Tabl. Vers.), pl. 206, 1797. [Name and figure only.] — Cuvier, Tabl. Elém. Hist. Nat. Anim., p. 421, AN 6 [1797 (489).] Sole species, *Lima alba* Cuvier with *Ostrea lima* Linnaeus in synonymy. — Gardner, U. S. G. S., Prof. Paper 142-A, p. 52, 1926. "Type: *Ostrea lima* Linnaeus." — Vokes, Tulane Studies in Geol., Vol. 1, No. 2, p. 75, 1963. "Type species by subsequent tautonymy (Lamarck, 1801) *Ostrea lima* Linnaeus, 1758 = *Lima squamosa* Lamarck, 1801, Recent, apparently world wide in warmer waters."

Type species (by tautonymy, Cuvier, 1797). — *Ostrea lima* Linnaeus (in the synonymy of *Lima alba* Cuvier). [*Ostrea lima* Linnaeus, Syst. Nat., ed. 10, p. 699, 1758. "Habitat in O. meridionali." Ref. to "Argenv. Conch. t. 27, f. E." This was illustrated without specific name by Bruguière, 1797, pl. 206, fig. 4 and it was described under the name of *Lima squamosa* by Lamarck, 1801, and by Deshayes, Encyl. Méth., Vol. 3, p. 345, 1832. Also illustrated by Sowerby, Reeve's Conch. Icon., Vol. 18, *Lima*, sp. 10, pl. 2, fig. 10, 1872 (as *Lima squamosa* Lamarck). For a discussion of *Ostrea lima* Linnaeus see Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 186-187, 1952; also Vokes, 1963, pp. 75-76.]

Range. — Triassic to Recent. Shallow to deep water.

Description. — Shell equivalve, inequilateral, biconvex, oblique, auriculate, edentulous, usually gaping anteriorly; the anterior region larger than the posterior, in which the umbones are situated. Posterior auricle larger than or equal to the anterior. Hinge-line straight, short. Area triangular, with a central ligament pit. Adductor impression large. Two small pedal impressions. (Arkell, W. J., Palaeogeographical Society London, Vol. 83, Corall. Lamell., Pt. 3, p. 128, 1931.)

Remarks. — Most members of this group are ornamented with radial ribs which may be nearly smooth or scaly. The exterior of others may be nearly smooth.

Lima is represented by abundant species in beds of Mesozoic age but their number declined during the Cenozoic. Only three species are known to occur in beds of Pliocene age in California, and these are rarely found. The genus is here recorded from the San Diego Formation for the first time. Species of *Lima* are widely distributed in the seas at the present time; eleven species have been reported living in west American waters.

Species of this genus can swim by clapping the valves together and expelling currents of water from the mantle cavity. Some species spin "nests" in which they are enclosed.

SUBGENUS *LIMARIA* LINK

Limaria Link, Beschreib. Nat.-Sammlung Univ. Rostock, Abt. 3, p. 157, May 17, 1807. Species cited include "*L. inflata*." — Winckworth, Proc. Malacol. Soc. London, Vol. 19, Pt. 3, p. 116, November, 1930. "I here choose *inflata* as type." — Hertlein and Strong, Zoologica, Vol. 31, Pt. 2, No. 5, p. 66, 1946. Type as designated by Winckworth.

Mantellum Bolton, Mörch, Cat. Conch. Comtes de Yoldi, Fasc. 2, p. 57, 1853.

Not *Mantellum* Röding in Bolton, Mus. Bolt., p. 160, 1798.

Winckworthia Glibert and Van De Poel, Mém. Inst. Roy. Sci. Belgique, Deuxième Sér., Fasc. 78, p. 49, 1965. "Type. — (Ice désigné), *Ostrea tuberculata* Olivi, 1792." [Zool. Adriatica, p. 120. "Abita nei fondi arenosi misti del mar dirimpetto alla spiaggia occidentale." Ref. to Gualtieri, Test., Tab. 88, fig. FF.]

Type species (by subsequent designation, Winckworth, 1930). — *Limaria inflata* Link founded on Chemnitz (490), Conchyl. -Cab. Bd. 7, pl. 68, fig. 649, lit. a [cited as "641.a" by Link], 1784. "Küste von Guinea und an den Stranden der westindischen Zuckerinseln." [= *Ostrea tuberculata* Olivi, 1792.]

Range. — Early Cretaceous (Neocomian) to Recent.

Description. — Shell of medium size (larger ones about 40 mm high), moderately thin, oblique, posterior margin bulging; submargins not impressed; usually somewhat inflated, gaping anteriorly and often more so posteriorly; sculptured with rather fine ribs of variable size, often scaly; ligament pit broadly triangular; a small but well developed pit beneath the posterior ear and usually a weaker one under the anterior ear; foot without byssus or retractor.

Remarks. — *Limaria* is here recorded from the San Diego Formation for the first time.

Species of this subgenus, at the present time, live in temperate and tropical waters. One species lives in Californian waters.

Promantellum Iredale (491) differs but little from *Limaria* except that the valves of the type species may be more widely gaping.

Submantellum Olsson and Harbison (492), with the type *Lima orbignyi* Lamy, differs from *Limaria* in the greater inflation of the valves, which gape but slightly anteriorly and lack any gape posteriorly.

A paper by Studnitz (493) deals with the anatomy of two of the small Atlantic species of *Limaria*.

Lima (Limaria) orcutti n. sp.

Plate 35, Figure 11; Plate 36, Figures 2-5;

Plate 57, Figure 10

Description. — Right valve, shell obliquely elliptical in outline, inequilateral, moderately convex; greatest length (anterior-posterior) about halfway between beak and ventral margin, gaping along the posterior dorsal margin; hinge short, oblique, the posterior ear pointed, a shallow sinus immediately below it; the anterior margin nearly straight above, but below it is gently rounded into the ventral margin, the outline of the posterior and ventral margin forms a broad arc; anterior umbonal slope rather steep, the posterior slope rather gentle; the valves are sculptured with about 35 to 40 fine, radial riblets, some vaguely paired, all separated by wider interspaces, ribs and interspaces widest on medial portion of the valve, the whole crossed by fine imbricating lines of growth; hinge elongately triangular, with a broad shallow, triangular ligamental pit, a triangular pit under the posterior ear, a shallow depression under the anterior one; the interior smooth, in some places the external ribbing is visible. Dimensions of holotype: Height (beak to ventral margin) 43 mm, length approximately 35.5 mm (posterior side imperfect), convexity (left valve) approximately 9.6 mm.

Type specimen. — Holotype and paratype in Los

Angeles County Museum.

Type locality. — Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U. S. G. S., topog. map, San Ysidro quad., rev. 1953.)

Range. — Middle Pliocene (San Diego formation).

Occurrence in San Diego Fm. — L.A.M. 305, 305C, 319.

Remarks. — This species is represented in the present collection by five valves, fairly well preserved, and by a number of fragments. The largest of the valves, a right valve, is selected as holotype.

This new species bears a general resemblance to *Lima hemphilli* Hertlein and Strong (494) which now lives in adjacent waters but the new species has fewer, coarser, more widely spaced ribs, the greatest length of the valves (anterior-posterior) is at a point about midway between the beak and the ventral margin rather than above the middle, the hinge plate is relatively broader and the posterior ear is much less acutely pointed.

The general features of the hinge are more like that of *Lima orbignyi* Lamy (495), but the shell of the new species is much more elongated, less inflated and the valves gape posteriorly.

The general outline of this new species is somewhat like that of *Lima auaua* Dall, Bartsch, and Rehder (496), from Hawaii, but the character of the ribbing appears to be quite different.

SUPERFAMILY OSTREACEA RAFINESQUE (497)

FAMILY OSTREIDAE RAFINESQUE (498)

Shell porcelaneous, inequivalve, dimyarian when young, monomyarian when adult, with posterior adductor impression in each valve; edentulous (or obscurely so); attached by cementation by the umbo or by the whole outer surface of the left valve to rocks, roots of trees or other objects; valves often much distorted due to fixation; valves usually close fitting, the left one usually larger and deeper, the right one often flat; sculpture alike on the two valves or different. Marine or brackish water. [Adapted from Dall in Eastman's edit. of Zittel's text book of Paleo., Vol. 1, pp. 451-452, 1913, and Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York) p. 171, 1961.] Triassic to Recent.

Remarks. — Newell (499) recently suggested that the pseudomonotids may have been ancestral forms giving rise to oysters. He mentioned that "true oysters are distinguished by loss of the foot and byssus during the prodissoconch stage, cementation by the left valve, and possession of a calcite shell. The last two characteristics apparently were not acquired before early or middle triassic time . . ."

An excellent summation of the various supraspecific group names in this family and their type species was published by Stenzel (500), and Baughman (501) published an annotated bibliography of oysters.

GENUS *OSTREA* LINNAEUS

Ostrea Linnaeus, Syst. Nat. ed. 10, p. 696, 1758. Many species cited including *Ostrea edulis* Linnaeus. — Dall,

Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 671, 1898. "Type *Ostrea edulis* Linné." — Lamy, Jour. de Conchyl., Vol. 73, No. 1, p. 12, 1929. "Type *O. edulis* L."

Ostreum DaCosta, Hist. Nat. Test. Brit., p. 154, 1778. Type designated by Winckworth (Proc. Malacol. Soc. London, Vol. 17, Pts. 2 and 3, p. 106, December 1926): "*T. vulgare*, da C. (here chosen) = *Ostrea*, L."

Ostracites Gmelin, Linn. Syst. Nat., ed. 13, p. 404, 1793. Type designated by Stenzel (Jour. Paleol., Vol. 21, No. 2, p. 178, March, 1947): "GT: *Ostrea edulis* Linné".

Ostraea G. B. Sowerby, Jr., Conch. Man., ed. 1, p. 75, and on table, 1839. Emendation of *Ostrea* Linnaeus. Suppressed as a synonym of *Ostrea* Linnaeus, see opinion 148, Internatl. Comm. Zool. Nomencl.

Monoeciostrea Orton, Nature (London), Vol. 121, p. 321, March 3, 1928. Type designated by Iredale (Great Barrier Reef Exped., 1928-29. Sci. Repts., Vol. 5, No. 6, Moll., Pt. 1, p. 394, 1939): "Logotype: *Ostrea edulis* Linné."

Type species (by Linnaean tautonymy; also designated by Schmidt, Versuch. Conch. Samml., pp. 69, 177, 1818). — *Ostrea edulis* Linnaeus. *Ostrea* with the type species, *Ostrea edulis* Linnaeus, was placed on the official list of generic names in Zoology by the Internatl. Comm. Zool. Nomencl. (Opinion 94, published October 8, 1926). [*Ostrea edulis* Linnaeus, Syst. Nat., ed. 10, p. 699, 1758. "Habitat in Oceano Europaeo." References include Gaultieri, Test., pl. 102, fig. B; Klein, Ostr., pl. 8, fig. 21; Bonaninni, Recr., t. 70. Also illustrated by Sowerby in Reeve's Conch. Icon., Vol. 18, *Ostraea*, sp. 8, pl. 5, figs. 8a-f, 1870. See also discussion of this species by Dodge (Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 192, 1952). The chalky deposits in the shell of this species were discussed by Korringa (Proc. Calif. Acad. Sci., Ser. 4, Vol. 27, No. 5, pp. 133-158, 2 figs. in text, 1951).]

Range. — Triassic to Recent. Recent, world-wide in temperate and tropical marine and brackish waters, from the intertidal zone to about 91 meters (50 fathoms) but usually abundant in less than 18 meters (10 fathoms). *Ostrea cochlear* is reported (502) from 2174 meters (1,189 fathoms).

Description. — Shell ovate, elongate or irregular in outline, attached by the left valve; upper valve flat or concave or sometimes convex, often unsculptured; lower valve convex, often plicated or foliaceous or with a prominent beak, dimyarian in juvenile state, monomyarian in adult (the anterior adductor lacking); ligamental cavity triangular or elongated; hinge toothless (except in very early stage of growth); margins smooth or with denticles; structure subnacreous, laminated, with prismatic cellular substance between the margins of the laminae. (Adapted from Tryon, Struct. and Syst. Conch., Vol. 3, 1884, p. 297, and Dall in Eastman's edit. of Zittel's Text-book of Paleo., Vol. 1, p. 450, 1913.)

Remarks. — The species of *Ostrea* have been the subject of a vast amount of literature. Much of this is a result of their economic importance because many of the species are highly valued as food. Many of the fossil forms are valuable aids as indicators of the geologic age of the strata in which they occur.

The majority of oysters including all the large, thick shelled forms live in shallow water or on bottoms exposed

between tides. The shape and sculpture of the shells of various species varies greatly because of the influence of the character of the bottom, the currents, or the chemical content of the waters in which they live.

A number of species of *Ostrea* have been described from strata of Tertiary age in California (503). One of these *Ostrea titan* Conrad, a huge species of Miocene age, has been reported to attain a length of 457 mm (18 inches). One species and two or possibly three varieties, live in the waters between the Bering Sea and San Diego, California (504). Along with these in some bays is a Japanese species *Ostrea gigas* Thunberg (or the variety *laperousei* Schrenck) and *Ostrea virginica* Gmelin (505) and others, introduced for commercial purposes. About a dozen species and subspecies of this genus live in tropical and subtropical waters of the western Americas (506). The Recent species in the Museum of Natural History in Paris were discussed by Lamy (507), those of Japan by Hirase (508) and those of Australia by Thomson (509).

Five species occur in the San Diego Formation.

Key to Species of *Ostrea*

A. Valves smooth *erici*

B. Valves with radial plications

a. Dorsal margins with denticles

b. Valves falcate in outline *megodon*

bb. Valves roundly trigonal to ovate in outline

c. Upper valve flat fitting into

pliate margins of the lower one . . . *vespertina*

cc. Upper valve slightly arched, margins interlocking with the lower one *angelica*

aa. Dorsal margins lacking denticles *veatchii*

Ostrea angelica Rochebrune
Plate 38, Figures 2, 3

Ostrea cumingiana Dunker of west American authors. — Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 58, pl. 5, fig. 6, 1950. Late Pliocene to Recent in the Gulf of California region.

Not *Ostrea cumingiana* Dunker, Zeitschr. f. Malakozool., Jahrg. 3, p. 48, March, 1846. "Patria ignota." — Philippi, Abbild. u. Beschreib. Neuer oder wenig gekannte Conchyl., Bd. 2, Heft 3, *Ostrca*, p. 81, Taf. 1, figs. 1, 2, 3, 4, October, 1846. "Patria ignota." — Hirase, Jap. Jour. Zool., Vol. 4, No. 2, p. 213, fig. 1, 1932 [as *Ostrea (Lopha) cumingiana*]. Omami, Oshima, Japan. — Adam and Leloup, Mém. Mus. Roy. Hist. Nat. Belgique, Hors Sér., Rés. Sci. Voy. Ind. Orient. Néerland, Vol. 2, Fasc. 20, p. 66, 1939. Manokwari.

Ostrea angelica Rochebrune, Bull. Mus. d'Hist. Nat. (Paris), Vol. 1, p. 241, 1895. "Baie de Los Angeles," east coast of Lower California. — Contreras An. Inst. Biol. (Mexico), Vol. 3, No. 3, p. 207, figs. 18 and 19, 1932. "Bahía de Los Angeles, Golfo de California." —

Keen, Sea shells of Tropical West America (Stanford Univ. Press), p. 65, fig. 117, 1958. "The Gulf of California to Ecuador." — Emerson and Hertlein, Trans. San Diego Soc. Nat. Hist., Vol. 13, No. 17, p. 353, figs. 3a-c, 1964. Isla Angel de la Guardia, ?Pliocene; Isla Carmen, Pliocene.

Type specimen. — Muséum Nationale d'Histoire Naturelle de Paris.

Type locality. — "Hab. Baie de Los Angeles, où elle forme des bancs d'une étendue considérable." [East coast of Lower California.]

Range. — Middle Pliocene to Recent. Recent from San Ignacio Lagoon to San Felipe, Lower California, and south to Mazatlan, Mexico. To Ecuador (Keen). [Not reported from the Panamic region by Olsson, 1961.] At the mouths of estuaries and bays, on stones, etc., where there is a current, but sheltered from breakers.

Occurrence in San Diego Fm. — C.A.S. 28888. S.D. 409. U.C.L.A. 303.

Original description. — *O. Testa aggregata*, plerumque irregulariter ovoideo rotundata, apice plus minusve attenuata, ad marginem undulato dentata; umbonis arcuatis, ligamento obliquo; valvis inaequalibus; valva inferiore subprofunda, intense adherens, circulariter radiatim costata; costis crassis subangulosis; valva superiore plana, centraliter corrugata, circulariter radiatim costata, costis irregularibus, obtusis plicatis, plicis imbricatis latis; extus albo viridula, intus albo nitida virescente; impressione subcentrali albo, trapezoido; marginibus lateralibus prope umbonibus, minutissime denticulatis.

Long. 0,080 mm. — Latit. 0,055 mm. — Crass. 0,023 mm. (Rochebrune.)

Remarks. — The fossils here referred to *Ostrea angelica* agree closely in all observable shell characters with Recent specimens of that species from the Gulf of California.

Recent specimens of *O. angelica* are usually oblong or rounded and the shell is rather thick. The lower valve is decidedly convex, the upper one only gently so. Both valves are sharply plicated over the distal half or one third of their surfaces which interlock along the margin, but the plications usually do not extend much beyond the pallial line on the interior of the valves. Exteriorly the color is light green with purplish radial streaks, the interior olive-green or shining whitish-green, occasionally entirely white. Denticles or transverse vermiculations are present on the margins from the ligamental pit usually to about a third the distance to the ventral margin. The muscle impression is posterior to the center, trapezoidal in shape, white. Large specimens in the collections of the California Academy of Sciences from Mejia Island, Gulf of California, are 122 mm high (beak to base), 95 mm long, convexity (both valves together), 41 mm.

Small specimens of *O. angelica* differ from *O. lurida laticaudata* Carpenter (510) in the greater thickness of the shell, the more convex upper valve which is more deeply plicated and along the margin interlocks downward with the lower valve rather than turning upward along the margin and fitting into the scalloped margin of the lower valve. Adult shells of *O. angelica* attain a much greater size and thickness than forms of *O. lurida*.

These same shell characters serve to separate *O. angelica* from *O. palmula* Carpenter, with which it occurs in the Gulf of California. The interior margins of Recent

O. palmula are blue or purplish blue, rather than tinted with green. Furthermore denticles often are present for a greater distance distally along the margins of *O. palmula* than on *O. angelica*.

The valves of *O. angelica* are generally larger, thicker, and more deeply plicated than those of *O. vespertina*. The plications on the exterior of the valves usually are present only on the distal half or third of the valves of *O. angelica*. On the lower valve these plicae extend from the margin to the broad unplicated area of attachment. The corresponding area of attachment on *O. vespertina* is usually much smaller. Furthermore the upper valve of *O. angelica* is more convex, the plications interlock downward along the margin, whereas on *O. vespertina* the upper valve is almost flat and fits into the scalloped edges of the lower valve similar to that of *O. lurida laticaudata* and *O. palmula*.

Ostrea caboblancoensis Weishord (511) described from strata of Pliocene age in Venezuela, bears a resemblance to *O. angelica*.

Ostrea angelica is reported here for the first time from the San Diego Formation. It is known to occur on terraces near San Antonio del Mar (512), in beds of Pliocene age, at Cedros Island and at Bahía Tórtolo (Turtle Bay), Lower California, and in strata of Pliocene and Pleistocene age in the Gulf of California region (513).

Ostrea erici Hertlein

Plate 38, Figures 4, 6, 8, 9

Ostrea erici Hertlein, Jour. Paleo., Vol. 3, No. 3, p. 295, September, 1929. A new name for *Ostrea tayloriana* Gabb, E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., 4th Ser., Vol. 15, No. 14, p. 428, pl. 33, fig. 3, 1926. [Not *Ostrea tayloriana* Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 34, pl. 12, figs. 60, 60a, 1866. "Miocene, from San Marcos Pass, near Santa Barbara", California. (Eocene.)] — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, p. 59, 1944. India Street at corner of Upas Street, San Diego. — Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper No. 222, pp. 65, 85, 104, 106, pl. 8, figs. 17, 18; pl. 9, figs. 1, 3, 4, 1950. [All figures represent specimens from Pliocene of Santa Maria district.] P. 104, India and Upas streets; p. 106, San Diego Formation, Pliocene. — Hertlein and Grant, Calif. State Div. Min., Bull. 170, Chap. 2, p. 60, 1954. San Diego Formation, Pliocene. — Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. San Diego Formation. Also Niguel Formation and others.

Type specimen. — No. 2094, California Academy of Sciences, Department of Geology, Type Collection.

Type locality. — From "mouth of big arroyo northwest of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California. Pliocene".

Range. — Middle Pliocene, southern California, and Lower California.

Occurrence in San Diego Fm. — C.A.S. 1135, 1183, 28892, 28893, 33334. L.A.M. 107, 124, 180, 309. S.D. 415, 2912, 2951. U.C.L.A. 309.

Description. — Shell moderately large, elongately to roundly trigonal, sometimes slightly expanded posteriorly; lower valve arched, right (upper) valve flat, both valves composed of rather coarse overlapping shell

laminae; ligamental pit on both valves elongately trigonal, rather small for the size of the shell; hinge plate at end of pit rounded and very slightly overhanging a shallow cavity; a small flat-topped indentation, corresponding to the lines of growth, occurs on each side of the ligamental pit; interior of shell smooth, large adductor impression rounded to semi-lunar, situated on the posterior side dorsally a little over one half the distance from the ventral margin to the beak; body cavity often bounded on each side by smooth, steep walls beyond which the shell tapers to a thin edge; margins smooth, no denticles present. Dimensions of the holotype: maximum length (beak to base), 100.5 mm, transverse length, 78 mm, convexity (both valves together), 36 mm.

Remarks. — This interesting oyster was collected chiefly in the strata exposed on and near Reynard Way and at the end of Arroyo Drive in San Diego. A representative specimen from Loc. 28893 (CAS), is 108 mm high (beak to base), transverse length, 94 mm, convexity (both valves together), 46.9 mm. It was first recorded from beds in northern Lower California by E. K. Jordan and Hertlein. Since then it has been recorded at a number of localities in beds presumably of about the same age as that of the San Diego Formation, namely, at Fourth and Broadway streets in Los Angeles (514), in the Sisquoc Formation and in the Cebada Member of the Careaga Formation in the Santa Maria district, in the Niguel Formation near San Juan Capistrano, in beds of middle Pliocene age on Carmen Island (515) in the Gulf of California, and questionably in the Gloria Formation in the Santa Rosalia area (516), east coast of Lower California. A portion of an upper valve from beds of Pliocene age on Maria Madre Island, Mexico, may be referable to the present species.

Ostrea erici is not similar to any Recent west American species.

Ostrea vespertina Conrad
Plate 39, Figures 1-3, 5-9

Ostrea vespertina Conrad, Jour. Acad. Nat. Sci. Philadelphia, 2nd Ser., Vol. 2, Pt. 4, p. 300, 1854. [February, 1854, in table of contents. Also stated to have been presented at Academy meeting March 7, 1854 (see An Index to Sci. contents of the Journal and Proceedings of the Acad. Nat. Sci. Philadelphia, 1812-1912, p. IX, 1913).] — Conrad, House Doc. 129, Projected Vol. 3, 33rd Congress, 1st Session, pp. 7, 15, July, 1855. P. 7, "Colorado desert," p. 15, "Locality. — Carrizo Creek, Miocene." Reprint by Dall, U. S. G. S., Prof. Paper 59, p. 168, 1909. — Conrad, in Blake, U. S. Pac. Railroad Expl., Vol. 5, Pt. 2, p. 325, pl. 5, figs. 36, 37, 38, 1857. "Carrizo creek, Colorado desert. Miocene." — Conrad, in Emory, Rept. U. S. Boundary Surv., Vol. 1, Pt. 2, p. 160, pl. 17, figs. 1a-d, 1857. "Carrizo Creek, and near San Diego, California (Miocene)." — Heilprin, U. S. G. S., 4th Ann. Rept., p. 315, pl. 71, figs. 2, 3, 4, 1881. "Carrizo Creek, Colorado Desert." (Conrad). Pliocene (Gabb). — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. 53, Pt. 1, p. 475, 1905. "Miocene. Carrizo Creek, and near San Diego, California." — Arnold and Anderson, U. S. G. S., Bull. 322, pp. 59, 148, pl. 23, fig. 10, 1907. "One mile north of Schumann." "Fernando (Pliocene)." — Arnold, U. S. G. S., Bull. 396, p. 77, pl. 24, figs. 4, 5, 1909. "Upper

Etchegoin formation; locality 4715." "Upper Miocene." [Pliocene.] P. 79, "Pacific Beach, Russ School, San Diego well, San Diego County (Henry Hemphill; W. H. Dall; Homer Hamlin; Delos and Ralph Arnold, and others)." "San Diego formation, lower Pliocene." — Arnold and Anderson, U. S. G. S., Bull. 398, pp. 129, 138, pl. 46, figs. 4, 5, 1910. [Same figures as in preceding reference.] — Hanna, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 18, p. 468, pl. 26, figs. 1, 2, 3, 1926. Coyote Mountain, Imperial Co., California, Pliocene. Also "San Diego," Pliocene. — E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 428, 1926. "San Diego," Pliocene. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, pp. 84, 85, 1929. "San Diego Pliocene." — Woodring, U. S. G. S., Prof. Paper 190, p. 42, pl. 8, figs. 1, 2, 3, 4, 8, 9; pl. 9, fig. 5, 1938. [Lectotype, figs. 3 and 8. Figs. 1, 2, 4, 9, from Barrett's oil well, south side of Imperial Co., California, Pliocene. Plate 9 fig. 5, from Third Street tunnel, Los Angeles, California.] P. 44, localities near San Diego "Pliocene San Diego formation." — Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, table opp. p. 112, p. 113, 1941. "San Diego." "Pacific Beach." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 59, 1944. "Near the intersection of Thirty-fourth and Tomkins Streets," San Diego, Pliocene. — Hertlein and Grant, Calif. State Div. Mines, Bull. 70, Chapt. 2, p. 60, 1954. San Diego Formation, Pliocene. — Emerson and Hertlein, Trans. San Diego Soc. Nat. Hist., Vol. 13, No. 17, p. 353, fig. 3 d-h (p. 356), 1964. Coyote Mountain, Imperial Co., California, Pliocene.

Type specimen. — Lectotype No. 4502, Academy of Natural Sciences of Philadelphia.

Type locality. — "Locality. Near San Diego, California. Dr. LeConte." "Miocene Species?"

Range. — Late Miocene (Nomland; Stanton); Pliocene.

Occurrence in San Diego Fm. — C.A.S. 1136, 1176, 1402, 1413, 28882, 28887, 28889, 28890, 28892, 34221, 36599. L.A.M. 107, 122, 124, 180, 302, 305, 305A, 309, 323, 208. S.D. 20, 37, 80, 331, 365, 408, 413, 446, 1142. U.C.L.A. 294, 296, 302, 310, 1382, 1383, 1385, 2420.

Original description. — Ovato-subfalcate, lower valve plicated or ribbed; hinge long and wide, sharp and somewhat pointed; ligament cavity wide, profound, minutely wrinkled; margins abrupt, cavity not very deep; muscular impressions large, impressed; upper valve flat, irregular; pallial impression crenulated throughout its whole extent, profoundly crenulated on the upper half of the shell. From beak to base $1\frac{7}{8}$; transversely $1\frac{1}{2}$. (Conrad.)

This species has a remarkable resemblance, externally, to a variety of *O. borealis*. The upper margin of the muscular impression is generally of a sigmoidal outline. (Conrad.)

Remarks. — Specimens of an oyster found in Pliocene strata at several localities in and near San Diego agree in all particulars with Conrad's original description of *Ostrea vespertina*. The lower valve is usually convex, bearing 5 to 10 plications, and the upper valve is flattish and fits down into the fluting around the margin. The margin below the ligamental area bears denticulations which sometimes occur along the margin for half the

length of the valve. Some of these specimens agree with illustrations of the upper valve selected by Woodring for the lectotype of this species.

Woodring, 1938, gave an extensive discussion of the problems concerned with the identification of *Ostrea vespertina*. Conrad originally gave the locality as "near San Diego," but some authorities consider it doubtful that Conrad's specimens came from this locality. Three years later (1857) he gave another description and illustrations and cited the species from "Carrizo Creek. Miocene." In another report the same year he described and illustrated specimens and gave the locality "Carrizo Creek, and near San Diego, California. (Miocene)."

Through the courtesy of Dr. Horace G. Richards, we were able to study the type lot of nine specimens of this species which are preserved in the Academy of Natural Sciences of Philadelphia. As mentioned by Woodring, the label does not bear the locality nor the name of the collector but the preservation is such as to indicate to him that they came from "evidently Carrizo Creek." This appears a reasonable conclusion. He illustrated only upper (right) valves but four lower (left) valves also are in the type lot. The lectotype selected by Woodring is a nearly flat upper valve, 37.7 mm long (slightly incomplete) and 48.6 mm high.

We also have studied a series of specimens from Loc. 33277A (CAS), collected by G. D. Hanna from an oyster reef in Painted Gorge on the north side of Coyote Mountain, Imperial Co., California. These specimens agree exactly with Conrad's illustrations of 1857 (plate 5, figs. 36-38) and possess similar denticulations along the upper margins. This feature was not mentioned by Woodring as being present on the lectotype but such denticulations are visible in shell layers along the anterior edge of the dorsal margin of that specimen and they are present on others in the type lot. Denticles are present on some valves from San Diego only 2 mm high (beak to base). The muscle impressions are often somewhat extended upward along the posterior end. Some of these specimens are virtually indistinguishable from Recent specimens of *Ostrea palmula* Carpenter (517), described one year later from the Gulf of California. Perhaps the average Recent specimen has the upper margins a little more fluted and the excavation under the beak of the lower (left) valve a little deeper but these features are variable in a large series. In any case, the specific name *vespertina* is the earlier of the two.

The chief difference between specimens from the San Diego Formation and those from the Carrizo Creek region appears to be size. Some specimens from San Diego are 75 mm high and 55 mm long (more circular forms may be 65 mm long). We have used the name *Ostrea vespertina* for our specimens because many left valves agree in all conchological characters with the lectotype which bears the earliest name proposed for a fluted oyster with a flattish upper valve and denticulate margins from strata of Pliocene age in southern California.

Woodring (1938, p. 44; 1940, p. 92), pointed out that some weakly plicated or nearly smooth valves of *O. vespertina sequens* Arnold (518), described from beds of late Pliocene age in San Joaquin Valley, California, are not separable from elongate specimens of *O. lurida* Carpenter (519) which, he suggested, may be a modern representative of that subspecies. The group of species

including *O. vespertina* and its subspecies *O. v. sequens*, *O. palmula*, *O. conchaphila* Carpenter (520) and *O. lurida* and its forms (521), have many shell characters in common and it appears reasonable to conclude that they represent a closely related group of species.

The large oyster from Imperial Co., California, named *Ostrea heermanni* by Conrad (522) has an ovate, flattish, very thick shell. The body cavity is fairly deep on the anterior side and the exterior flutings are reflected interiorly along the margins of rather thin valves, but not on thick valves. The growth lines are decidedly looped upward on each side of the ligamental area, distinctly different from those of *O. vespertina* which are but slightly or not at all looped upward.

Some authors have considered a close relationship to exist between *O. vespertina*, *O. haitensis* Sowerby, *O. heermanni* Conrad, and *O. wiedeyi* Hertlein. The latter three species bear a greater resemblance to *O. veatchii* Gabb and their similarities will be discussed in connection with that species. Studies of the type lot of *O. vespertina* and other specimens from the type locality, also the selection of a lectotype by Woodring, have furnished a basis for separating this species from typical *O. veatchii* with which it has been united by some authors.

Arnold (1909, p. 78) pointed out that "*O. vespertina* is smaller, relatively narrower, and usually more falcate in outline and carries plaits more regular in size and generally fewer in number than *O. haitensis*." Both Dall and Arnold pointed out that the west coast species closely resembles *O. sculpturata* Conrad (523) from the late Miocene and Pliocene of eastern United States. The illustrations of that species from Florida by Mansfield (524) are remarkably similar to some specimens of *O. vespertina* from the San Diego Formation. A subspecies, *Ostrea vespertina venezuelana* Weisbord (525), described from strata of Pliocene age in Venezuela, is very similar to some forms of *O. vespertina* from southern California.

The record of *Ostrea vespertina* cited as occurring in the Miocene of Ceylon by Deraniyagala (526) obviously is referable to *O. virleti* or one of that group. The species cited by Masson and Alencaster Ibarra (527) as "*Ostrea* sp. cf. *O. vespertina* Conrad" from Miocene beds of San Andres Tuxtela in the State of Vera Cruz, Mexico, is referable to one of the east American species. The record of "*Ostrea* cfr. *vespertina* Conr." cited by Khomenko (528) from beds of Miocene age in Kamtschatka, evidently is referable to some other species. Conrad's species was not cited by Slodkewitsch, 1938, in his comprehensive work on the late Tertiary fauna of that region.

Ostrea vespertina has been cited as occurring in beds of late Miocene age in central California and in the San Joaquin valley (529), but we have not seen specimens certainly referable to this species from strata of that age.

This species has been recorded as occurring in strata of Pliocene age as far north as the San Benito and San Juan Bautista quadrangles in California. It has been reported from beds of that age in southern California, Lower California, and south to Maria Madre Island, Mexico.

Ostrea veatchii Gabb

Plate 39, Figure 4;

Plate 40, Figures 1, 4, 5, 6

O[strea]. veatchii Gabb, Geol. Surv. Calif., Palaeo., Vol.

2, p. 34, pl. 11, fig. 59, 1866. — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11, "San Diego," p. 29, "about ten miles northward from San Diego," 1878. — Heilprin, in White, U. S. G. S., Fourth Ann. Rept., p. 316, pl. 72, fig. 1, 1884. (Copy of Gabb's illustration). — [?] Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 63, 1903 (as "*Ostrea veatchii?*"). "Pacific Beach" and "Russ School", San Diego, Pliocene. — Arnold, U. S. G. S., Prof. Paper 47, p. 28, 1906. "San Diego Formation". — Arnold, in Eldridge and Arnold, U. S. G. S., Bull. 309, p. 250, pl. 39, fig. 1, 1907. "Lower Pliocene, San Diego."

Ostrea vespertina Conrad, E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, pp. 417, 428-429, 1926 (in part). "San Diego", also Cedros Island, Bahía Tortólo (Turtle Bay), and near Elephant Mesa, Lower California, Pliocene.

Not *Ostrea vespertina* Conrad, 1874.

Ostrea haitensis Sowerby subsp. *vespertina* Conrad, Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 128, pl. 14, fig. 4, 1930. "The holotype of *O. veatchii* is figured."

Type specimen. — No. 4502, Academy of Natural Sciences of Philadelphia.

Type locality. — "Cerro Island, associated with *Pecten Veatchii*, *P. cerrosensis*, and the following species [*O. cerrosensis* Gabb]. Dr. J. A. Veatch."

Range. — Middle Pliocene, from San Diego, California, to Bahía Tortólo (Turtle Bay) and Cedros Island, Lower California.

Occurrence in San Diego Fm. — S.D. 6307.

Original description. — Shell large, subequivalve, varying from nearly equilateral to very oblique, the obliquity being always to the left side. Surface marked by ten or a dozen large, angular, radiating ribs, some of which arise at or near the beaks, the others branching from the first, or interpolated between them; the interspaces are angular, and the ribs are marked by more or less squamose plates, and occasionally these plates assume almost the character of spines; internally the ribs show only towards the margins. Hinge short, very broad and shallow; no crenulations or denticulations near the margin. Muscular scar large, suboval to subquadrate. (Gabb.)

Remarks. — Two valves from Pacific Beach agree with the form described as *Ostrea veatchii* Gabb. The largest of these is 125 mm long. The valves are deeply and sharply fluted and some of the flutings develop extensions into spines. Specimens such as these have been considered by several authors to be variants of *O. vespertina*.

Through the courtesy of Dr. Horace G. Richards, Academy of Natural Sciences of Philadelphia, we have been able to examine the type lot of *Ostrea veatchii*. The type is a comparatively thin (about 4 mm) lower valve, 75 mm high and 68 mm long, the upper anterior margin incomplete. The exterior is sculptured with about 10 angular, radiating ribs which at intervals develop into spines. Interiorly there is no recessed area under the hinge, the muscle impression is fairly large and rounded, and as mentioned by Gabb, there are no denticles along the margin of the valve. An upper valve, about the same size, gently convex, sculptured similar to the type, is in the type lot.

The gently arched upper valve, more numerous, spinose ribs which deeply interlock along the ventral

margin and the smooth margins totally lacking denticles are shell characters quite different from those of *O. vespertina* from its type locality. Some of the tubular spines on a specimen from Cedros Island in the collections of the Los Angeles County Museum (A.6573.54-2) are 28 mm long (see pl. 40, fig. 5). The shell of typical specimens is lamellar with irregular open spaces between the lamellae. Dr. Hendryk B. Stenzel mentioned to us that this kind of shell structure is similar to that of some members of the *Ostrea hyotis* group. We restrict the usage of the name *O. veatchii* to specimens agreeing in general shell characters with the type specimen. Among Recent west American oysters, the presence or lack of denticles along the margin below the hinge is a rather constant character.

Examination of about 50 specimens from Pliocene strata on Cedros Island, the type locality of *O. veatchii*, and of additional specimens from Bahía Tortólo (Turtle Bay), Lower California, reveals considerable variation. Some of these agree exactly with Gabb's type and lack denticles on the margin. Others, usually smaller, more trigonal or falcate forms have very fine denticulation only along the upper portion of the margin, others have denticulation similar to that on *O. vespertina*. Also occurring at Cedros Island are specimens agreeing in every way with *O. angelica*. The variation in this series from Cedros Island is such as might lead one to question whether perhaps some of these are hybrids between *O. veatchii* and *O. angelica*. For the present we believe it desirable to retain *O. veatchii* as a separate taxon at least until the relationships of west American oysters are better known.

Exteriorly some specimens of *O. angelica* bear a close resemblance to *O. veatchii* and that probably explains Dall's (530) citation of the latter as occurring Recent in the Gulf of California. The shell of *O. angelica* is usually thicker, the flutings usually do not extend to the dorsal third of the valves and do not develop into spines, interiorly the margins below the ligamental pit are finely denticulate, and the muscular impression is semicircular in outline.

A large rounded, thick (40 mm at thickest), flattish valve illustrated by Gabb (1869, pl. 17, figs. 21, 21a; Heilprin, 1884, pl. 72, fig. 1) under the name of *Ostrea veatchii*, which accompanied the type lot of *O. veatchii*, is 123 mm long, 131 mm high, maximum thickness about 42 mm. It closely resembles specimens of *O. heermanni*. In the text (pp. 60, 61) following the caption to the figures of this specimen, Gabb mentioned the occurrence of thick, flat oysters from the east coast of Lower California. It seems probable that the valve discussed here came from that region.

Ostrea wiedeyi Hertlein (531) described from early Miocene strata on Santa Rosa Island, California, bears a strong resemblance exteriorly to *O. veatchii*. The shell of this Miocene species is much thicker and on some specimens the growth lines loop upward to some extent on each side of the ligamental area. Another feature noticed on the interior of these fossils is the presence of a depression just below the hinge on the posterior side of the body cavity.

Loel and Corey (532) considered *O. wiedeyi* to be identical with *O. loeli* Hertlein which they placed as a variety of *O. vespertina*. The thick shell, shape of body cavity, and muscle impression, as well as the shape of the

hinge line of *O. wiedeyi* bear a greater resemblance to *O. heermanni* than to typical *O. vespertina*. *Ostrea wiedeyi* bears a close resemblance to *Ostrea haitensis* Sowerby as illustrated by Maury (533) from the late Miocene of Trinidad but the west coast species differs in lacking the transverse vermiculate threads on the margin below the hinge.

Ostrea veatchii, at times, has been placed in the synonymy of *O. haitensis* Sowerby (534), a species occurring in strata of Miocene age in the Caribbean region. The west American shell represents a similar but distinct species with a thinner shell and without denticles or transverse threads on the margin. The *Ostrea haitensis* group includes species such as *O. gatunensis* Brown and Pilsbry described from beds of Miocene age in the Panama Canal Zone and perhaps in a general way includes west American fossil forms such as *O. wiedeyi* Hertlein, *O. loeli* Hertlein and *O. howelli* Wiedey. *Ostrea haitensis* closely resembles *O. virleti* Deshayes, a large plicated oyster which occurs in strata of late Tertiary age in the Mediterranean and Indian Ocean regions. The distribution of *O. virleti* was discussed by Davies (535) and its relationships by Cox (536).

We are uncertain what species is represented by Dall's record (537) of *Ostrea veatchii* from late Tertiary beds on Atka Island and Unga Island, Alaska. The same can be said for the records of *O. veatchii* from Miocene strata in western Washington cited by Weaver (538). *Ostrea fisheri* Dall (539), a large round form, living in the Gulf of California and known from Pliocene to Recent in that region, is believed to be closely related to *O. hyotis* Linnaeus, an Indo-Pacific species and to *O. thomasi* McLean which lives in Floridan waters.

SUBGENUS AGEROSTREA VIALOV

Agerostrea Vialov, Acad. Sci. URSS, Compt. Rend. (Doklady), Nouv. Sér., Vol. 4 (13), No. 1 (105), p. 20, 1936. — Stenzel, Jour. Paleo., Vol. 21, No. 2, p. 168, 1947.

Type species (by original designation). — "type: *A. unguolata* Schloth." [= *Ostracites unguolatus* Schlottheim Taschenbuch f. Mineralogie herausgegeben von C. C. Leonhard, Jahrg. 7, Abt. 1, p. 112, 1813. Ref. to "Knorr P. II. T. D. VII. F. 3 und 6. Petersberg." Illustrated by Coquand, Monographie du genre *Ostrea*. Terrain Crétacé (Marseille), p. 58, Atlas, pl. 31, figs. 4-15, 1869. — Carter, Palaeontology, Vol. 11, Pt. 3, p. 463, pl. 85, figs. 2, 3; pl. 86, fig. 6; pl. 87, fig. 8, 1968.]

Range. — Late Cretaceous to Recent.

Original description. — Coquille longue, étroite, incurvée, avec une surface médiane lisse. (Vialov.)

Remarks. — Many supraspecific group names have been proposed in the Ostreidae. Some authors have placed *Ostrea megodon* in the subgenus *Lopha* Roding in Bolten (540) which has as type *O. crista-galli* Linnaeus, a Recent species. Recently, Dr. H. B. Stenzel suggested (pers. comm.) that *O. megodon* could be placed in *Agerostrea* Vialov which was based upon a species originally described from beds of Maestrichtian, late Cretaceous age. We have not seen specimens of the type species of *Agerostrea* but some of the illustrations referred to *O. unguolata* by Coquand (see especially his pl. 31, figs. 6, 7, 8) closely resemble *O. megodon* in general shape and shell

characters.

Many species, especially of Jurassic and Cretaceous age, have been assigned to *Lopha*, as have others in the Cenozoic. Recent species of that genus occur in shallow tropical and subtropical marine waters.

There is no agreement among authors as to which, if any, Mesozoic species should be assigned to *Lopha*. Gillet (541), following Douvillé, considered typical "*Alectryonia*" Fischer de Waldheim (type, *Ostrea crista-galli* Linnaeus) [= *Lopha*] to predominate from late Cretaceous to Recent.

Beginning in middle Jurassic a group of oysters developed which were predominant during late Jurassic and early and middle Cretaceous. These are arcuate in outline with long, narrow beaks and numerous extremely angular plicated margins and they are less equilateral in form than *Lopha*. The genus *Arctostrea* Perivinquière (542) was proposed for these with the type species *Ostrea carinata* Lamarck. Some authors have placed *Arctostrea* in the synonymy of *Lopha* but these taxa represent quite distinct supraspecific units.

The name *Rastellum* Schröter, 1782, was discussed and rejected by Stenzel (1947, pp. 181-182). The history of *Rastellum* as a genus name is rather involved but usage of it by authors subsequent to Schröter is much later than the name *Lopha*.

Ostrea (Agerostrea) megodon Hanley Plate 38, Figures 1, 5, 7

Ostrea megodon Hanley, Proc. Zool. Soc. London, Pt. 13, for 1845, p. 106 (issued February, 1846). — Sowerby, Conch. Icon., Vol. 18, *Ostraea*, species 24, pl. 12, figs. 24a, 24b, 1871. "Peru." — E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 427, pl. 28, fig. 1, 1926. "Pliocene beds at Bernstein's abalone camp on southeast side of Cedros Island. Pliocene." Also other localities.

Ostraea gallus Valenciennes, Zool. Voy. Venus, pl. 21, figs. 1, a-d, 1846. [No description.]

Ostrea cerrosensis Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 35, pl. 11, fig. 61, 1866. "with the preceding species". [That is, *Ostrea veatchii* Gabb from "Cerro Island, associated with *Pecten veatchii*; *P. cerrosensis*, and the following species."]

Ostrea megodon Hanley subsp. *cerrosensis* Gabb, Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 130, pl. 14, fig. 1, 1930. [One of Gabb's type specimens illustrated as a lectotype.]

Ostrea (Lopha) megodon Hanley, Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 66, fig. 123 (Scammon's Lagoon), 1958. Scammon's Lagoon, Lower California, to Paita, Peru, Recent.

Ostrea (Alectryonia) megodon Hanley, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 172, pl. 23, figs. 3, 3a ("Bayovar, Peru"), 1961. Gulf of California to northern Peru, Recent. — Olsson, Neogene Mollusks from Northwestern Ecuador (Paleo. Res. Inst.: Ithaca, New York), p. 39, pl. 1, figs. 1-1b (Punta Gorda, Ecuador, Pliocene), 1c (Quebrada Mellisa, Burica Peninsula, Panama, Pliocene), 1964.

Type specimen: British Museum (Natural History).

Type locality. — "Hab. Peru (Cuming). Mus. Cuming."

Range. — Pliocene to Recent. Recent from Scammon's Lagoon, west coast of Lower California, Mexico, to San Felipe and Puerto Peñasco in the Gulf of California and south to Paita, Peru, in 15 meters (8 fathoms) to 112 meters (61 fathoms).

Occurrence in San Diego Fm. — S.D. 6307. U.C.L.A. 2420.

Original description. — Ost. Testâ falcata, glabrâ, solidâ, subaequalvi, pallidè livido-purpurascens, margines versùs plicatâ; plicis anticis 5 aut 6, maximis, subangulatis; posticis minimis, angulatis, paucis, subobsoletis; margine valde plicato, intusque magis minusve scabro; natibus incurvatis; superficie internâ albo-virescente, nunquam margaritaceâ; cicatrice satis magnâ, reniformi. Long. 5 poll. (Hanley.)

Remarks. — Two small specimens of *Ostrea megodon* are present in the collections from Pacific Beach. One from Loc. 6307 (SD) is 42.3 mm long and 29.3 mm wide. The other specimen, from Loc. 2420 (UCLA), is 39.6 mm long (beak to base), 21 mm wide, convexity (not including flutings), 12 mm. These specimens, except in size, agree in all observable shell characters with Recent specimens of *O. megodon* from tropical west American waters, in shape, muscle impressions, and denticulated dorsal margins. There is variation in the development of denticulation on Recent specimens of this species. On some, denticles occur along the margin for about one half the distance from the beak to the ventral margin, on others these are well developed below the beak but soon become weaker ventrally.

The measurement of the type specimen of *Ostrea megodon* given as "5 poll" is equivalent to approximately 126.6 mm. The largest Recent specimen in the Academy's collection is a left valve collected by Don Frizzell at Brazo Ramon estuary, south of Sechura, Peru. It is 107 mm long (beak to base). A Recent specimen from Bahía Tortólo (Turtle Bay), Lower California, is 78 mm long (beak to base), 40 mm wide, the convexity (not including flutings), 19.5 mm. Galtsoff (543) mentioned that specimens of this species in Panama attain a length of 15-16 cm, but this appears to be an exceptional size. Olsson (1961; 1964) has discussed Recent and fossil specimens of this species from northwestern South America and Panama.

The name *Ostrea gallus* Valenciennes, 1846, accompanied illustrations of a fluted oyster but was not accompanied by a description. The illustrations obviously appear to be referable to *O. megodon* and this interpretation has been accepted by most authors.

Gabb in 1869 described *Ostrea cerrosensis* from strata of Pliocene age on Cedros Island, Lower California. Stewart later discussed and illustrated one of Gabb's type specimens and placed it as a subspecies of *O. megodon*. The reason for retaining *O. cerrosensis* as a subspecies was based upon the difference in size between the type specimens of *O. megodon* and *O. cerrosensis*. The illustration given by Gabb, said to be natural size, is approximately 59 mm long. The dimensions of the specimen illustrated by Stewart as lectotype of *O. megodon cerrosensis* were given as 53 mm long, 66 mm high, convexity (not including flutings), 15 mm.

A specimen of *Ostrea megodon* collected by E. K.

Jordan from strata of Pliocene age on Cedros Island is 79 mm long (beak to base) and a larger specimen collected from the same general area by Mrs. Joyce Roderick is 101 mm long (beak to base). Specimens from beds of Pliocene age in Ventura County, Loc. 90 (CAS), are 99 mm long. All these specimens, although not so large as the type specimen of *O. megodon*, agree with that species in all observable shell characters. We therefore place *O. cerrosensis* Gabb in the synonymy of Hanley's species, as did Dall.

Woodring, Bramlette, and Kew (544), assigned the subspecific name *Ostrea megodon cerrosensis* to an oyster with broad shallow plications from late Pleistocene beds in the Palos Verdes Hills in Los Angeles Co. The degree of width and depth of fluting varies in a series of Recent specimens from tropical west American waters and therefore we are inclined to consider as referable to *O. megodon* those fossil specimens which differ from Recent ones only in the degree of fluting. Large Recent specimens have 5 to 6 rounded well developed flutings along the anterior margin. The exterior is colored greenish and purple, and the interior whitish and green.

Ostrea megodon has been recorded from beds of late Tertiary age in the Caribbean region but most of those records are now referred to closely related forms which have been described as separate species.

Ostrea paramegodon Woodring (545) from the Bowden beds of late Miocene age in Jamaica, was described as smaller, less curved and with shallower folds than *O. megodon*. Woodring stated that except for size, the fossil from the Gurabo Formation, Miocene, in the Dominican Republic, illustrated by Maury (546), greatly resembles the west American *O. megodon*.

The species cited by Olsson (547) under the name of *O. megodon* from Miocene strata in Costa Rica, was later placed in the synonymy of *O. messor* Maury (548) which was described from strata of late Miocene age in Trinidad. Maury also described *O. messor* var. *caimita* and *O. messor* var. *tabiquita*. A subspecies from the Miocene of Columbia was described by Weisbord in 1929 as *O. messor colombiensis*. We have examined specimens from Miocene beds in Columbia identified by Anderson (549) as *O. "megodon"*. These are smaller and less curved in outline than most Recent shells of this species which we have observed.

Undoubtedly a number of forms from strata of late Tertiary age in the Caribbean region and the west American *O. megodon* form a closely related group. The fossil forms vary somewhat in size, curvature and magnitude of flutings. Just how many of these should retain separate specific or subspecific designation is open to question. Weisbord (550) recently discussed several members of this group.

SUPERFAMILY ANOMIACEA RAFINESQUE (551) FAMILY ANOMIIDAE RAFINESQUE (552)

Shell large or small, generally irregular and distorted, attached by close contact to various objects by means of a calcified byssal plug passing through a round hole or foramen in the umbone of the right valve, remaining attached throughout life or only in the early stages. Valves rounded or subcircular, variously inflated, but generally more or less irregular because of fixation, nac-

reous, and often with a platy or micaceous texture, thin or heavy. Hinge edentulous but sometimes provided with large, divergent resilial processes or crura simulating hinge teeth. Ligament internal, attached to resilial processes along the hinge margin or to deep scars. Interior of the left valve has two or three rounded or elongated scars which represent the attachment impressions of the byssal and retractor muscles. (Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 175, 1961). Jurassic to Recent.

The members of the Anomiidae live between tides or in comparatively shallow water attached to other shells or to rocks.

This family is represented in the San Diego Formation by two genera.

Key to Genera of Anomiidae

- A. Upper valve with one large and one small muscle impression *Pododesmus*
- B. Upper valve with one large and two small muscle impressions. *Anomia*

GENUS ANOMIA LINNAEUS

Anomia Linnaeus, Syst. Nat., ed. 10, p. 700, 1758.

Numerous species cited including *Anomia ephippium*.

— Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, pp. 774, 781, April, 1898. "Type *A. ephippium* Linné." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 240, 1931. Type (as indicated by Children, 1823): *Anomia ephippium* Linnaeus.

Type species (designated by Schmidt, Versuch der Conchylien-Sammlung, pp. 71, 177, 1818). — "Typ. *Anomia ephippium*" [Linnaeus]. [*Anomia ephippium* Linnaeus, Syst. Nat., ed. 10, p. 701, 1758. "Habitat in M. Mediterraneo & America." Illustrated by Chemnitz, Syst. Conchyl. Cab., Bd. 8, p. 81, pl. 76, figs. 692, 693, 1785. Cited from "Mittelländischen See", also "Ostund Westindischen Meeren." See discussion of this species by Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 198-199, 1952. "The form to which Linnaeus gave the name *ephippium* is that common on the west coast of France."]

Range. — Jurassic to Recent. Recent cosmopolitan, except in Arctic and Antarctic. From the intertidal zone to 3001 meters (1094 fathoms). Usually in intertidal or shallow water.

Description. — Shell subrounded or irregular in outline, rather thin, attached with a calcified byssal plug which passes through a sinus in the right valve; left (upper) valve with one large and two smaller muscle impressions; hinge edentulous.

Remarks. — Five species of *Anomia* have been reported from Cenozoic strata of California, one of which occurs in the San Diego Formation. One Recent species lives in west American waters between San Pedro, California, and Paita, Peru. In tropical and subtropical waters it is accompanied by one or possibly two species of *Anomia*, whose systematic status is doubtful.

The exterior of valves of *Anomia* may be smooth or

with radial ribs which on the upper valve sometimes are spinose. Merrill (553) discussed the variation in sculpture of *Anomia aculeata* Gmelin, an east American species.

The species of this genus are attached to rocks, shells, or other objects and often acquire sculpture corresponding to that of the object to which they are attached. Often only upper valves are found on the beach, or as fossils, because those become loose and are washed away, whereas the lower valve remains attached.

Boulenger (554) mentioned that the byssal plug of members of this genus apparently corrodes surfaces to which it is attached and as a result the shell often lies sunk into a pit of its own making.

The Recent species of *Anomia* in Great Britain have received special study by Winckworth (555). Loosanoff (556) discussed the metamorphosis of the east American *A. simplex* d'Orbigny.

Anomia peruviana d'Orbigny

Plate 40, Figure 2; Plate 41, Figure 8

Anomia peruviana d'Orbigny, Voy. dans l'Amér. Mérid., Vol. 5, Pt. 3, p. 673, 1846. — Phillippi, Abbild. u. Beschreib. Conchyl., Bd. 3, No. 8, p. 131 (1), *Anomia*, pl. 1, figs. 2, 3, 1850. "Patria: Peru," Recent. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 240, pl. 12, figs. 2, 5, 1931. Various localities cited, Pliocene to Recent. — Hertlein and Strong, Bull. Amer. Mus. Nat. Hist., Vol. 107, Art. 2, p. 177, 1955. "Pinas Bay, Panama." Recent. Also earlier records. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 80, fig. 152, 1958. Monterey, California, to Paita, Peru. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 177, pl. 24, figs. 2-2f, 1961. Lower California to northern Peru.

Type specimen. — British Museum (Natural History). Type locality. — "aux environs de Payta (Pérou)."

Range. — Late Miocene or early Pliocene (in Ecuador, Olsson) to Recent. Recent from San Pedro California, to Punta Peñasco in the Gulf of California and south to Paita, Peru, and the Galápagos Islands, from low tide to 110 meters (60 fathoms) on rocks or on shells.

Occurrence in San Diego Fm. — C.A.S. 1137, 1400, 1413. L.A.M. 305, 305A, 305C.

Original description. — Coquille presque arrondie, un peu carrée, plus longue que large, très-déprimée, marquée en dessus de quelques indices de côtes rayonnantes peu prononcées, nombreuses. Sa couleur est verdâtre très-pâle ou rosée; son intérieur est verdâtre, le ligament entièrement vert. La valve inférieure a ses bords désunis sur une grande largeur. Diamètre, 33 millimètres. (d'Orbigny.)

Remarks. — Three upper valves of an *Anomia* are present in the Academy's collections from Pliocene strata at San Diego. The largest one, 36.6 mm from beak to base, is smooth but the other two bear radial ribs. These shells are so similar to Recent specimens of *Anomia peruviana* that there appears to be no reason to doubt their identity. A few small valves referable to this species are in the collections of the Los Angeles County Museum from Locs. 305, 305A and 305C (LAM).

Seven left (upper) valves in the collections of the

Los Angeles County Museum, the largest one 59 mm high, were collected by Charles Sternberg at Pacific Beach. According to the label these were from beds of Pliocene age. The excellent preservation of the specimens as well as the softness of the matrix leads us to question whether these valves may have been collected from beds of Pleistocene age which overlie the Pliocene strata at Pacific Beach.

Recent specimens of *Anomia peruviana* vary in shape and in sculpture. They may be smooth exteriorly or they may bear well developed radial ribs occasionally bearing very short spines. Exterior sculpture of the shell of *Anomia* may simulate that of the object to which it is attached. Partly because of the multiplicity of forms resulting from such situs this species has received a number of names in the literature. The following are generally considered to be synonyms: *Anomia hamillus* Gray, *A. larbas* Gray, *A. alectus* Gray, *A. lampe* Gray, *A. pacilus* Gray, "*Anomya*" *simplex* Mabilie.

Anomia fidenas Gray has been considered to be a synonym of *A. peruviana* by many authors but Olsson (557) recently accorded it specific status.

Anomia adamas Gray (558), originally described from the Galápagos Islands and Lord Hood's Island, was said by E. K. Jordan (559) to differ from *A. peruviana* in that the two distal muscle impressions of the upper valve are equidistant from the umbo rather than nearly in a straight line. It might be questionable whether or not this criterion can be relied upon consistently to separate the two species. Keen (1958, p. 80) considered *A. adamas* to be a valid species, a distinction based chiefly on a radial ribbing pattern on some specimens. A problem in connection with *A. adamas* is the locality record "Lord Hood's Island." There is a "Hood Island" in the Galápagos group and "Lord Hood Island" in the Gambier Island group. Several authors (560) have cited this species as occurring in the southwestern Pacific. Whether it occurs in both west American and western Pacific Islands is open to question.

Anomia limatula Dall was based upon large smooth valves presumably from beds of Pleistocene age at Pacific Beach. It is probably not more than subspecifically different from *A. peruviana* and some authors consider them to be identical.

Anomia subcostata Conrad was originally described from beds now believed to be of Pliocene age, in Imperial Co., California. Hanna (561) mentioned the great variation in a series of specimens and suggested that it is quite possible that Conrad's species may not be separable from some of the Recent west American species.

Anomia peruviana has been reported from strata of middle Pliocene age at Bahía Tortola (Turtle Bay), Lower California and from deposits of Pleistocene age from southern California to Peru. At the present time it lives in quiet bays where it is attached to rocks or to empty shells by a byssus which extends through a notch in the lower valve. The pearly upper valves, which may be white, green or yellow, are often found upon the beaches where the species occurs. The lower valves often are not found, or occur but sparsely among empty shells. This is probably a result of the method of attachment.

Anomia limatula Dall

Anomia limatula Dall, Proc. U. S. Nat. Mus., Vol. 1, p.

15, July 1, 1878. — Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 27, 28, 1878. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 785, pl. 35, fig. 19, April, 1898. "Pacific Beach near San Diego, Stearns." "Pliocene." Also other localities, Pliocene and Pleistocene. — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. 53, Pt. 1, p. 50, 1905. "Pliocene. San Diego, California."

Type specimen. — "Holotype" No. 7949, United States National Museum. ["Plesiotypes" No. 154341 United States National Museum (Schuchert, Dall, et al.). Specimens labeled "Original lot" by Henry Hemphill are Nos. 695, 695a, b, c, California Academy of Sciences Department of Geology type collection.]

Type locality. — "late Tertiary deposits of the Californian coast," San Diego. [Cited later (1878, p. 27) from "Strata of the San Diego Peninsula," also "strata on the mainland" "To the eastward of the town, or what is known locally as the 'railroad land'."]

Range. — Pleistocene.

Remarks. — Four upper (left) valves of *Anomia limatula* labeled by Henry Hemphill "Original lot" from "Foot of 30th street" in San Diego are in the collections of the California Academy of Sciences. These evidently came from beds of Pleistocene age. Schuchert, Dall, et al., cited the age of the "Holotype" as "Pliocene" but there is no evidence that it came from beds of that age. Dall (1898) illustrated a specimen collected by Stearns at Pacific Beach and cited the age as Pliocene. The valve illustrated by Dall appears to be identical with those collected by Hemphill.

The species which Dall (1878, pp. 27, 28) listed with *Anomia limatula* indicate Pleistocene age for that assemblage and Arnold (562) later cited it as occurring only in deposits of that age. We know of no evidence indicating that *Anomia limatula* occurs in the San Diego Formation.

GENUS *PODODESMUS* PHILIPPI

Pododesmus Philippi, Wiegmann's Archiv f. Naturgesch. for 1837, Jahrg. 3, Bd. 1, p. 385. Sole species: *Pododesmus decipiens* Philippi. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, pp. 770, 774, 1898. Type: *P. rudis* Broderip. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1 p. 241, 1931. Type (by monotypy): *P. decipiens* Philippi = *Placunanomia rudis* Broderip, Cuba.

Type species (by monotypy). — *Pododesmus decipiens* Philippi, 1837, p. 386, pl. 9, figs. 1a, 1b, 1c, 1d. "Havana." [= *Placunanomia rudis* Broderip, 1834, illustrated by Reeve, Conch. Icon., Vol. 11, *Placunanomia*, sp. 2, pl. 1, figs. 2a, 2b, August, 1859. "Hab. West Indies; Broderip. Havana; Philippi." Also, Abbott, American Seashells (Van Nostrand Co., Inc.: New York), p. 372, pl. 38, fig. b, 1954. — Olsson and Petit, Bull. Amer. Paleo., Vol. 47, No. 217, p. 529, pl. 77, fig. 1, 1964. Key West, Florida, Recent.]

Range. — ?Eocene; late Oligocene, or early Miocene to Recent. Recent from the intertidal zone to about 73 meters (40 fathoms), occasionally deeper.

Description. — Valves rounded, radiately grooved or wrinkle-ribbed (but not plicated); lower (right) valve with an open or sometimes nearly closed byssal foramen;

upper (left) valve with one striated byssal impression and one muscle impression.

The crurum on the lower valve of the type species of *Pododesmus* (described by Olsson and Petit) has "a single crural process which arises as a ridge along the posterior side of the central chalky area and at the dorsal margin becomes enlarged into a prominent knob, its dorsal face folded or bilobate in shape and carrying the attachment scar of the ligament".

Remarks. — This genus differs from *Placunanomia* in possessing an open byssal foramen in the lower valve, although small or sealed over in the type species (563), and in lacking large, well developed cardinal crura. It differs from *Anomia* in possessing only one muscle impression (in addition to the byssal impression), rather than two.

Knowledge of the generic and subgeneric assignment of fossil specimens is often doubtful where the preservation is imperfect.

Beu (Trans. Roy. Soc. New Zealand, Zool., Vol. 9, No. 18, p. 228, 1967) recently placed *Placunanomia*, *Pododesmus* and *Monia* in a new subfamily Placunanomiinae.

Species referred to *Pododesmus* were described by von Ihering (564) from the lower Patagonian beds, believed to be of Eocene age, in Patagonia. The muscle impressions on those fossils were imperfectly preserved and confirmation of the generic assignment is desirable. Soot-Ryen described *Pododesmus puntarenensis* (565) from beds of Tertiary age at Punta Arenas, Chile.

Key to Subgenera of *Pododesmus*

- A. Lower valve with a small (sometimes nearly closed) foramen *Pododesmus* s. s.
- B. Lower valve with a large open foramen *Monia*

SUBGENUS *MONIA* GRAY

Monia Gray, Proc. Zool. Soc. London for 1849, p. 121, issued between January and June, 1850. Several species cited including *Placunanomia macrochisma* Broderip, *P. cepio* Broderip, *P. alope* Broderip, *P. patelliformis* Linnaeus, *P. zealandica* Gray, *P. ione* Gray, *P. colon* Gray. — Beu, Trans. Roy. Soc. New Zealand, Zool., Vol. 9, No. 18, p. 229, November 2, 1967. Type as designated by Kobelt.

Type species (designated by Kobelt, Illustr. Conchylienbuch, Bd. 2, p. 376, 1881). — "Typus ist *Placunanomia zealandica*. Quoy (Taf. 112 fig. 4) von Neuseeland." [*Anomia zealandica* Gray in Dieffenbach's Travels in New Zealand, Vol. 2, p. 261, 1843. New Zealand. Illustrated by Reeve, Conch. Icon., Vol. 11, *Placunanomia*, sp. 4, pl. 1, fig. 4, 1859. New Zealand. — Suter, Man. New Zealand Moll., p. 845, pl. 56, figs. 1, 1a, 1913. — Beu, 1967, fig. 2e, f.]

Range. — Late Oligocene or early Miocene to Recent.

Description. — The shell of this subgenus differs from *Pododesmus* s. s. in possessing a large byssal opening

and in that the large perforation of the lower valve only slightly embraces the large thin plug.

Beu (1967, p. 229) pointed out that the resilial crurum on the type species of *Monia* is single and with only a dorsal resilial surface. The interior in many of the Recent species is usually greenish or brownish in coloration.

Remarks. — *Monia* is reported to occur in western North America and Japan from late Oligocene or early Miocene to Recent, in Europe from Miocene to Recent, in England, Pliocene to Recent. It is living in New Zealand and Australia and probably occurs in strata of late Tertiary age in that region.

According to Keen (566) the species described as *Placunanomia inornata* by Gabb from beds of Eocene age in California, and later assigned to *Monia* by Vokes (567), is an *Anomia*.

Hayami (568) recently referred two species of early Cretaceous age in Japan to *Monia*. The muscle impressions of the species were not seen and therefore this record of *Monia* in the Cretaceous needs confirmation.

Pododesmus (Monia) macrochisma Deshayes Plate 40, Figure 3; Plate 41, Figures 9, 12, 13

Anomia macrochisma Deshayes, Rev. Zool., Soc. Cuvierienne, December, 1839, p. 359. — Deshayes, Guerin's Mag. de Zool., 1841, pl. 34. — Philippi, Abbild. u. Beschreib. Conchyl., Bd. 3, Heft 8, *Anomia*, p. 132 (2), pl. 1, fig. 4, November, 1850 (as *Anomia macroschisma*). "Patria: Mare glaciale ad Kamtschatka, Insulas Aleutas, et sinus Ochotensis."

Placunanomia macroschisma Deshayes, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "well at San Diego." "Pliocene." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. "well-digging in stratum B²," San Diego well. — Cooper, Seventh Ann. Rept. Calif. State Mineral., p. 260, 1888. "Pl. — San Diego well." — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, August, 1889. Dall's record (1874) cited. — Orcutt, quoted by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) cited.

Pododesmus (Monia) macroschisma Deshayes, Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 780, April, 1898. "Pliocene of San Diego, California, Hemphill." "Pliocene of the San Diego well." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 117, 1903. "Pliocene. — San Diego well (Dall)." — Waterfall, Univ. Calif. Publ., Bull. Dept. Geol. Sci., Vol. 18, No. 3, table opp. p. 78, 1928. "San Diego Pliocene."

Pododesmus macroschisma Deshayes, Arnold, U. S. G. S., Prof. Paper 47, p. 28, 1906. "San Diego formation . . . at Pacific Beach, north of San Diego." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 65, pl. 26, figs. 1a, 1b, (Recent), 1924. "Pliocene of San Diego." — Carson, Pan-Amer. Geol., Vol. 43, No. 4, p. 268, 1925. "San Diego fauna." Pliocene. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 242, 1931. "San Diego well, Balboa Park, San Diego (Dall, 1874)."

Monia macroschisma Deshayes, J. P. Smith, Proc. Calif.

Acad. Sci., Ser. 4, Vol. 3, p. 181, 1912. "San Diego-Purisima." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 151, 1919. "San Diego" Pliocene.

Pododesmus macrochisma Deshayes, Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) cited.

Type specimen. — Location unknown to the present authors.

Type locality. — "Kamtschatka." Recent.

Range. — Miocene to Recent. Recent from the Bering Sea to Cape San Lucas, Lower California, and Santa Inez Bay in the Gulf of California. From intertidal zone to 73 meters (40 fathoms). Also Miocene to Recent in Japan (569); Recent from Lat. 38° to 46° N., in Japan Sea, and 39° to 47° N. in Pacific. Kamtschatka (570), Pliocene to Recent.

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 1176, 1178, 1179, 1183, 1402, 1413, 1414. L.A.M. 122, 124, 302, 305, 305A. U.C. A-8333. U.C.L.A. 301, 305, 2420.

Original description. — Testa irregulariter ovata, inaequalivalvi, albo-iridula, irregulariter plicata; valvae superiore convexa, inferiore plana, suprema late perforata, foramine integro, marginibus acutis plicatis, valvis intus submargaritaceis, superiore maculamagna satirate viridi ornata. (Deshayes, 1839).

Remarks. — Numerous specimens, all single valves, in the collections from the San Diego formation are referable to this species. The largest specimen, a well preserved left (upper) valve, from Loc. 305 (LAM) is 77 mm high, from dorsal to ventral margin, and 94 mm wide; the smallest one is about 5 mm high. A large Recent specimen 102 mm high and 105 mm wide was reported from Morrow Bay, California (see Min. Conch. Club South. Calif., No. 190, p. 21, 1959). The fossil specimens vary in thickness. Some are rather coarsely sculptured with radial ribs, others bear fine sculpture as shown in Reeve's illustrations of "*Placunanomia*" *ceprio* Gray and *P. alope* Gray.

Fitch (571) stated that specimens of *Pododesmus* occurring on abalone shells in southern California are referable to the species described by Gray as *Placunanomia ceprio* (572), a species generally placed in synonymy of *Pododesmus macrochisma*. Gray described *P. ceprio* as follows: "Scars 2, far apart; upper very large, ovate, longitudinal, central; lower smaller, oblong, oblique, rather behind the upper," "Plug large, flat, broad. Notch large wide." Reeve illustrated a specimen under this name and stated: "Shell orbicular, radiately minutely striated, everywhere wrinkle-indented; transparent white; orifice rather large."

Placunanomia alope Gray (573), also described from California, has well defined radial sculpture as stated by Reeve, "In this species the ribs have an irregular character, disposed in waved radiating wrinkles."

The separation of *P. ceprio* and *P. alope* from forms of *P. macrochisma* is based chiefly upon the thinner shell and finer sculpture. However, valves similar to *P. alope* from San Miguel Island, California, in the collections of the California Academy of Sciences, are accompanied by large, thick, rather coarsely sculptured valves. The thickness of the shell and the development of coarse or fine radial sculpture (occasionally obsolete) varies greatly depending upon the situs. Frizzell (574) mentioned a

specimen which grew in an empty tube of a *Teredo*.

F. S. MacNeil mentioned (pers. comm.) that specimens referred to *Pododesmus macrochisma* from California generally have a larger byssal foramen than those from Alaska. We have examined this feature in a series of shells from Bering Sea to Lower California, Mexico. We have observed two rather thick Recent shells from Kodiak Island, Alaska, in which the foramina are comparatively small. However, somewhat thinner shells with larger foramina also are present in the collection from the same locality. Illustrations representing this species by Russian (575) and by Japanese authors (576) reveal rather large foramina. Size of the foramen does not appear to be consistently different in northern and southern forms.

It is true that some specimens from west American waters are similar to *P. ceprio* and others to *P. alope* but the variation in a large series is so great that there appear to be no criteria to rely upon for separating the shells into two or three species unless certain forms are arbitrarily selected to represent various species. An examination of a large series of specimens of *P. macrochisma* in the Smithsonian Institution, and the type specimen of *P. alope*, led Carpenter (577) to conclude that it "proves that these forms are among the many varieties of *P. macrochisma*" (578). More recently Burch (579), after studying a large series of specimens of *Pododesmus* from Puget Sound and from Monterey, California, stated that he could find no basis for the recognition of more than one species.

We have observed large coarsely ribbed specimens referable to *P. macrochisma* which occur in beds of late Pliocene age in Ventura Co., California.

A variety (580) of *P. macrochisma* was described by Kanehara from Hokkaido, Japan, from beds now believed to be of Pliocene age.

Pododesmus newcombei Clark and Arnold (581) was based upon a fossil from Vancouver Island, British Columbia, in beds referred to late Oligocene age. The type measures approximately, length 35 mm, height, 29 mm. It was described as differing from *P. macrochisma* in the smaller size and fewer, coarser, radial ribs separated by wider interspaces.

Pododesmus foliata Broderip (582), a Recent tropical west American species, is sculptured with fine ribbing and the color of the interior is brown.

SUBCLASS TELEODESMATA DALL
ORDER PACHYDONTIDA STEINMANN
SUPERFAMILY CHAMACEA BLAINVILLE (583)
FAMILY CHAMIDAE BLAINVILLE (584)

Shell substance three-fold, the inner layer porcelainous and tubular, the middle obscurely prismatic, the external cellulo-crystalline with reticulated tubules and an inconspicuous epidermis; valves unequal, irregular, one of them sessile; closed, usually rounded in form with conspicuous sculpture, often differing in the opposite valves; adductor scars subequal, elongate, pedal scars minute, distant; ligament and resilium external in a deep groove, parvicar, opisthodetic; area distinct, prosodetic; beaks more or less spiral, prosogyrous; pallial line simple; hinge-plate heavy, arcuate; hinge frequently with a minute or obsolete posterior lamina, chiefly in the fixed valve;

cardinals one or two in the free valve, two with an intermediate socket in the fixed valve; the anterior cardinal broad, usually deeply grooved or multifid, the posterior simple, long, and curved parallel with the dorsal border. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 3, pp. 541-542, 1895). Late Cretaceous to Recent.

Remarks. — The supraspecific units of this family have been reviewed by Nicol (585). Many of the Recent west American species of Chamidae were reviewed by Pilsbry and Lowe (586) and others. Yonge recently discussed the "Form, Habit and Evolution in the Chamidae (Bivalvia) with reference to conditions in the rudistids (Hippuritacea)" (Phil. Trans. Roy. Soc. London, Ser. B. Biol. Sci., No. B. 775, Vol. 252, pp. 49-105, figs. 1-31, February 16, 1967).

GENUS *CHAMA* LINNAEUS (587)

Chama Linnaeus, Syst. Nat., ed. 10, p. 691, 1758. Several species cited including *Chama lazarus* Linnaeus. — Odhner, Kon. Svenska Vetensk. Akad. Handl., Bd. 59, No. 3, p. 75, 1919.

Type species (designated by Schmidt, Versuch Conchyl. Samml., pp. 63, 177, 194, 1818). — "Typ. *Chama Lazarus*. No. 11. v. Born. tab. 5, fig. 12-14". [*Chama lazarus* Linnaeus, 1758, p. 691. "Habitat in Mediterraneo, Americano." Ref. to "Rumph. mus. t. 48, f. 3", "Argenv. Conch. t. 23, f. F. I.", "Brown, jam. t. 40, f. 9." Illustrated by Reeve, Conch. Icon., Vol. 4, *Chama*, sp. 4, pl. 2, figs. 4a-b, 1846. For a discussion of *Chama lazarus* see Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 138, 1952.]

Range. — Late Cretaceous to Recent. Recent, shore to about 160 meters (86 fathoms). One species cited from a depth of 1250 meters.

Description. — Shell thick, attached at umbo of left valve which is often cornucopia-shaped; very inequivalve, the upper one the smaller; beaks prosogyrous, turned to the right; ornamentation concentrically foliaceous and irregularly lamellate or spinose; hinge tooth of upper valve thick, curved, received between two teeth in the opposite valve; ligament external but more or less sunken in a groove; adductor impressions large; margin usually finely crenellated.

Remarks. — *Chama* is separated from *Pseudochama* Odhner, type *Chama cristatella* Lamarck, which is attached by the right valve and has the beaks twisted to the left. Yonge mentioned (1967, p. 56) that some species in the Chamidae may be attached by either the right valve or the left valve and that genera cannot be erected on this basis. However, he stated that "It is also convenient, regardless of species, to refer to '*Chama*' and '*Pseudochama*' thereby denoted individuals attached by these valves."

Douvillé (588) suggested that *Chama* may have been derived from *Corbis* Cuvier [*Fimbria* Megerle von Mühlfeld] by attaching one valve for support.

Only three species of *Chama* have been reported from the Tertiary of western United States, one in the Oligocene of western Washington, and one each in the early Miocene and in the middle Pliocene of California. Four species have been recorded from beds of late Pliocene age in the Gulf of California region. This genus is here recorded from the San Diego Formation for the first time.

The species of *Chama* live chiefly in warm marine

waters. Ten species live in west American waters, only one of which ranges north to California.

Chama pellucida Broderip Plate 43, Figure 12, 15

Chama pellucida Broderip, Proc. Zool. Soc. London for 1834, p. 149, issued April 3, 1835. — Broderip, Trans. Zool. Soc. London, Vol. 1, p. 302, pl. 38, fig. 3, 1835. Original locality cited. — Reeve, Conch. Icon., Vol. 4, *Chama*, species 32, pl. 6, fig. 32, 1847. Original locality cited. — Woodring and Stewart, in Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, p. 38, and list opposite p. 78, pl. 14, figs. 1-4, 10, 1941. *Pecten* zone, San Joaquin Formation, Kettleman Hills, California, late Pliocene. — Abbott, American Seashells (D. Van Nostrand Co., Inc.: New York), p. 393, pl. 37, fig. a, 1954. Oregon to Chile. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 225, pl. 33, figs. 2, 2a; pl. 34, fig. 5, 1961. Oregon to Chile, Recent.

Type specimen. — Syntypes Nos. 1950-11.1.63-65, British Museum (Natural History).

Type locality. — "Hab. ad Peruviam. (Iquiqui)." "Dredged up attached to stones, *Mytili*, and turbinated shells, at a depth varying from nine to eleven fathoms, from a bottom of coarse sand; and also found under stones at low water mark."

Range. — Late Miocene (Castaic Formation; Stanton, 1966); middle Pliocene to Recent. Recent, western Oregon (Lat. 44° N.) to Cedros Island, Lower California, Mexico. Santa Elena, Ecuador, to Tocopilla, and Juan Fernandez Island, Chile. Intertidal zone to 46 meters (25 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A, 318, 319.

Original description. — *Chama testa albâ roseo seu rubro frucatâ vel strigatâ, lamellis frequentibus, frondibus elongatis pellucidis; intus albâ, limbo crenulata.* (Broderip.)

Remarks. — This species is represented in the San Diego Formation by numerous small specimens, the largest is a left valve 17 mm high. A fragment 25 mm long bears spines similar to those on *Chama frondosa*. A number of small, eroded specimens are probably referable to this species.

Chama frondosa is here reported from the San Diego Formation for the first time. It has been reported from California in beds of Pliocene age at Los Angeles, in the San Joaquin Formation in Kettleman Hills, (and what is probably this species) from the Santa Maria district. It has been reported in beds of late Pliocene age in the Gulf of California region but we have not seen specimens.

The reported distribution of this species from Oregon to Chile, at the present time is an unusual one. Specimens from California agree closely with illustrations of this species by Broderip and by Reeve. We have not seen specimens from south of Cedros Island, Mexico, in North American waters. The species was not included by Keen in her volume on tropical west American shells. Confirmation of the identity of the form from California and Oregon with specimens from Peru is desirable.

The hinge teeth of this species in an early stage of development, have been illustrated by Dall (589). Grieser (590) published a paper dealing with the animal of *Chama*

pellucida and a recent paper by Yonge (1967) contains a detailed discussion of various features of this species.

Chama chilensis Philippi (591), described from beds of Quaternary age in Chile, was said to differ from *C. pellucida* in possessing less projecting concentric lamellae, which lack frondose extensions, as well as in differences in details of the hinge.

ORDER HETERODONTIDA NEUMAYR
SUPERFAMILY CRASSATELLACEA MENKE (592)
FAMILY CRASSATELLIDAE MENKE

Shell porcellaneous, solid, subtriangular to oblong, with convex or compressed umbones, the anterior side shorter, higher and rounded, the posterior contracted, flattened, pointed, or subtruncate. Hinge strong with large cardinal teeth and laterals. Ligament internal, attached to a resilifer groove between the cardinal teeth. Surface smooth or with growth line sculpture, sometimes concentrically undulate especially over the umbones. Pallial line simple, the adductor scars usually impressed. Ventral margin smooth or crenate. [Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 179, 1961.] Cretaceous to Recent.

The members of this group live chiefly in warm temperate and tropical waters. This family is well represented in the Eocene of western North America, but only a few species have been reported from the later Tertiary and Quaternary in this region.

GENUS *CRASSINELLA* GUPPY

Crassinella Guppy, Geol. Mag., Dec. 2, Vol. 1, p. 442, October 1874. Sole species, *Crassinella martinicensis* d'Orbigny. — Keen, Proc. Malacol. Soc. London, Vol. 23, Pt. 1, p. 30, 1938. "Genotype (by monotypy): *Crassinella martinicensis* (D'Orbigny 1853) (= *Crassatella martinicensis* D'Orbigny, 1853)." — Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 72, 1953. "Type by monotypy: *Crassinella martinicensis* d'Orbigny." — Korobkov, Metodicheskoe Rukovodstvo Po Tretichnym Molluskam Plantinchatobabernye [Lamellibranchiata] (Leningrad), p. 137, 1954. Type, *Crassatella martinicensis* d'Orbigny.

Not *Crassinella* Bayle, Explic. Carte France, Vol. 4, Fasc. 1, Explic. t. 105, 1878.

Pseuderiphyla Fischer, Man. de Conchyl., p. 1022, June 15, 1887. Sole species, *Crassatella martinicensis* d'Orbigny.

Type species (by monotypy). — *Crassinella martinicensis* d'Orbigny in Sagra, Hist. . . . Cubana, Vol. 7 (Moll., Vol. 2), p. 288, [1845], Atlas, pl. 27, figs. 21, 22, 23, 1842. — Maury, Bull. Amer. Paleo., Vol. 10, No. 42, p. 330 (178), pl. 42 (31), fig. 2, 1925. "Matura," Trinidad, "Upper Pliocene." — Jung, Bull. Amer. Paleo., Vol. 55, No. 247, p. 352, pl. 22, figs. 1, 2, 1969. Trinidad, early Pliocene.

Range. — Eocene (593) in Europe and Argentina, late Oligocene (594) in the Americas, to Recent. Recent in warm temperate and tropical waters, from 1 to 73 meters (40 fathoms), and reported to a depth of 712 meters (390 fathoms).

Description. — Shell small, solid, subtrigonal with

the lateral sides straight and subequal, the umbones flattened with the small beaks pointing backwards or opisthograte. Anterior side rounded, the posterior more excavated, concave, its end obtuse or pointed. Ligament is largely internal, the pit for the resilium forming a deep socket in the hinge plate; it is bordered in each valve by two strong cardinal teeth on the anterior side. Left valve with a strong posterior lateral tooth bordered above by a long linear socket. External surface smooth or with strong, concentric lamellations. Pallial line simple, the ventral margins plain. (Olsson and Harbison, 1953.)

Remarks. — This genus with small, trigonal, flattish, concentrically sculptured valves, is here reported from beds of Pliocene age in California for the first time. However, it is known to occur in beds of that age in Costa Rica and Ecuador.

The earliest geologic record of occurrence of *Crassinella* in California is that of "*Crassinella* cf. *C. mexicana* Pilsbry and Lowe" from strata of approximately middle Miocene (595) age.

Six species have been reported from beds of Pleistocene age in southern California and Lower California. Four species have been reported living in tropical and subtropical west American waters. The number of valid forms will probably be reduced when the relationship of the various west American species is known.

Crassinella branneri Arnold
Plate 43, Figures 24, 25, 28, 29

Astarte (*Crassinella*) *branneri* Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 127, pl. 18, fig. 12, June 27, 1903.

Crassinella branneri Arnold, Woodring, Bramlette, and Kew, U. S. G. S., Prof. Paper 207, p. 82, pl. 36, figs. 1-6, 1946, "characteristic of the Palos Verdes sand."

Type specimen. — No. 162527, United States National Museum.

Type locality. — "from the upper San Pedro series at Los Cerritos," California. "Pleistocene."

Range. — Middle Pliocene to late Pleistocene.

Occurrence in San Diego Fm. — L.A.M. 305.

Original description. — Shell small, subtrigonal, equivalve, inequilateral, convex, thick; umbo small, sharp; anterior dorsal margin straight to anterior extremity, where it meets the arcuate ventral margin in an angle; posterior dorsal margin evenly arcuate, sloping down to rounded, posterior extremity; surface sculptured with numerous angular, concentric undulations or ridges; lunule long, narrow, extending to anterior extremity, and circumscribed by a narrow, angular ridge; ligament external, not prominent; two prominent cardinal teeth in right valve; one in left; no laterals; pallial line entire, running from the middle of adductor scars; adductor scars subequal, small. Dimensions. — Long. 10 mm; alt. 8.9 mm; diam. 5 mm. (Arnold.)

Remarks. — Several valves of this *Crassinella* were collected by G. P. Kanakoff near the Mexican boundary. These agree well with the original description and appear to be the species identified with *Crassinella branneri* by Woodring, Bramlette, and Kew.

The original illustration depicts a left valve, apparently rather thick and with a rather wide apical angle. There is a discrepancy in the dimensions given in the text and those on the explanation to the plate. Dr. W. P.

Woodring kindly informed us (written comm., October 16, 1968) that the type specimen is 9.7 mm long. This corresponds rather well with the dimension given as 10 mm by Arnold on page 127 (text). Dr. Woodring also informed us concerning the hinge and lateral armature both of which agree well with the present specimens.

The anterior margin of the left valve of this species is grooved toward the ventral margin and a posterior lateral socket is parallel to the posterior margin throughout its length and into which the margin of the right valve fits. Some authors refer to the inner lamina (more strongly developed ventrally) as a posterior lateral. A similar anterior socket is present on the right valve.

There is considerable variation in the valves in the present collection. The larger ones are less concave posteriorly and are less strongly sculptured. The apical angle varies from about 78° to 82°.

Crassinella branneri bears a close resemblance to *C. pacifica* C. B. Adams (596), differing chiefly in the narrower posterior ventral end of the shell. *Crassinella mexicana* Pilsbry and Lowe (597) is nearly equilateral and the posterior dorsal margin is but slightly concave in outline.

Crassinella quintinensis Manger (598), described from beds of Pleistocene age at San Quintín, Lower California, appears to be referable to *C. branneri*. Specimens from the type locality were identified as *C. branneri* by E. K. Jordan and they reveal no noticeable differences in shell characters from Arnold's species.

Woodring, Bramlette, and Kew, mention that a "small race" of *C. branneri* lives in Scammon's Lagoon, Lower California. We have observed specimens of *C. mexicana* from that locality and further south at San Hipolito Point, some of which in profile approach *C. pacifica*. They may be but a subspecies of *C. pacifica* to which nomenclatorial status such forms were referred by Hertlein and Strong (599) and by Hoffstetter (600).

SUPERFAMILY CARDITACEA FLEMING (601) FAMILY CARDITIDAE FLEMING

Shell suborbicular to subquadrangular, often cordate, usually heavy, with large, prominent umbones, anteriorly directed and varying in position from submedian to nearly terminal, the anterior side commonly the shorter. Sculpture consists typically of strong, radial ribs, usually noded, the surface covered by a brown, hairy periostracum. Ligament external. Hinge plate curved, usually with two cardinal teeth in each valve, the posterior one elongate and with the lateral teeth absent or more or less degenerated. Pallial line simple, the ventral margin more or less fluted or crenated by the ends of the radial ribs. Byssus usually present. [Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 184, 1961.] Triassic to Recent.

This family is represented by numerous species in the Paleogene of western North America, but the number was reduced in the Neogene. Four genera are present in the San Diego Formation. At the present time, carditids with large, thick shells live in tropical and subtropical waters, but small forms, which also occur in warm waters, are abundant in temperate and even Arctic waters. Frequently viviparous.

Freneix (602) discussed the development of the ligament and the hinge characters of the Carditidae and Yonge (603) discussed the functional morphology and evolution within the Carditacea.

Key to Genera of Carditidae

- A. Shell high and subtrigonal
 - a. Hinge of left valve with an anterior lateral tooth. *Miodontiscus*
 - aa. Hinge of left valve lacking an anterior lateral tooth. *Cyclocardia*
- B. Shell oblong or elongately trapezoidal
 - a. Ventral margin of valves folded inward. *Milneria*
 - aa. Ventral margin of valves not folded inward. *Glans*

GENUS CYCLOCARDIA CONRAD

Cyclocardia Conrad, Amer. Jour. Conch., Vol. 3, No. 2, p. 191, September 5, 1868. *Cardita borealis* Conrad and *Cardita ventricosa* Gould cited. — Lamy, Jour. de Conchyl., Vol. 66, No. 4, p. 293, 1922. "Type *V. borealis* Conrad." — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Paper No. 3, p. 150, 1930.

Arcturus Sowerby, Zool. Beechey's Voy., Moll., p. 152, 1839. *Arcturus rudis* Humphrey MS in synonym of *Cardita borealis* Conrad.

Not *Arcturus* Berthold in Latreille, 1827. Crustacea. Not *Arcturus* Curtis. Lepidoptera.

Scalaricardita Sacco, Moll. Terr. Terz. Piemonte e Liguria, Pt. 27, p. 22, September, 1899. Species cited, "*Miodon* (an *Scalaricardita*) *scalaris* (Sow.)", and in the synonymy, *Cardita producta* Michelotti, 1847.

Type species (designated by Stoliczka, Mem. Geol. Surv. India, Palaeont. Indica, Ser. 6, Cret. Fauna South. India, Vol. 3, Pelecypoda, pp. XX, 281, 1871). — "Type, *C. borealis*, Con." [Amer. Mar. Conch., p. 39, pl. 8, fig. 1, 1831. Illustrated by Stearns, Proc. U. S. Nat. Mus., Vol. 13, No. 813, p. 215, pl. 16, fig. 8, 1890. (Fig. of type). — Abbott, Amer. Seashells, p. 379, pl. 28, fig. t, 1954.]

Range. — Middle Oligocene (604) to Recent. Recent from 18 to 2195 meters (10 to 1200 fathoms).

Original description. — Rounded, equivalve, radiately costate, covered with a rough epidermis; hinge with two robust teeth in the left valve, directed obliquely backward, the posterior one elongated and slightly curved; anterior tooth of the right valve rudimentary; pallial impression entire. (Conrad, 1868.)

Remarks. — *Cyclocardia* Conrad is here retained in a generic category because of the unsettled state of nomenclature concerning the type species of *Cardita* Bruguière (605) and *Venericardia* Lamarck. The species assigned to *Cyclocardia* are usually rounded trigonal and covered with a rough periostracum. The cardinal tooth on the right valve of some species is bifid or grooved, but on others this feature is only faintly developed.

Cyclocardia has been cited from widely separated regions. It occurs in the Arctic, temperate, sub Antarctic, and Antarctic (606) regions. Finlay and Marwick (607) stated that in New Zealand, *Cyclocardia* first appeared in the Duntroonian, late Oligocene, and last appeared in the

Awamoan, middle Miocene. Sieber (608) cited it from late Tertiary beds in the Vienna basin. Hirayama (609) listed 32 species, Recent and fossil, of small "*Venericardia*" from Japan and stated that probably half of these are referable to *Cyclocardia*. It has been reported from strata of middle Oligocene age in Germany, and in western North America *Cyclocardia* first appeared in late Oligocene or early Miocene time. Recent species in this region occur from the Arctic to slightly south of San Diego, California. One species living in tropical west American waters was recently assigned to *Cyclocardia* by Keen (Sea Shells of Tropical West America, p. 109, 1971). Chavan (610) briefly discussed the occurrence of *Cyclocardia* and pointed out that it is essentially an American group.

Woods (611) long ago called attention to the similarity existing between the late Tertiary species of Europe, *Cardita scalaris* Sowerby, the type species of *Scalaricardita*, and *C. ventricosa* Gould. The similarity is so great that it leads to the placement of *Scalaricardita* Sacco in the synonymy of *Cyclocardia* as was recently done by Sieber.

Key to Species of *Cyclocardia*

- A. Radial ribs 14 to 17; dorsal-ventral elongation *occidentalis*
- B. Radial ribs 18 to 20; anterior-posterior elongation *ventricosa*

Cyclocardia occidentalis Conrad
Plate 43, Figures 4-6, 9-11

C[ardita]. occidentalis Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 267, February, 1855. — Conrad, U. S. Pac. Railroad Expl., Vol. 6, Pt. 2, No. 2, p. 73, pl. 5, fig. 24, 1857. "Locality. — Santa Barbara, California."

Cardita monilicosta Gabb, Proc. Acad. Nat. Sci. Philadelphia, Vol. 13, p. 371, November, 1861. "From the Tertiary (probably Miocene) of Santa Barbara, Cal."

Venericardia borealis Conrad, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "well at San Diego." "Pliocene." — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 269, 1888. "Pl. — San Fernando, Los Angeles County; Santa Barbara to San Diego." — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, 1889. Dall's record (1874) cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, pt. 1, p. 48, 1944. Dall's record (1874) cited.

Not *Venericardia borealis* Conrad, 1831.

Venericardia monilicosta Gabb, Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 28, 1878. P. 28 "well-digging in stratum B2, "San Diego, California." — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 86, 1889. Dall's record (1878) cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 60, 1919. Dall's record (1878) cited. — Arnold, U. S. G. S., Bull. 321, p. 32, pl. 14, fig. 2, 1907. "Fernando formation, Bath-house Beach, Santa Barbara." "Fernando (Pliocene)." [Pleistocene.]

Venericardia ventricosa Gould, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 129, 1903. "Pliocene. — San Fernando; Santa Barbara to San Diego (Cooper): San Pedro; Santa Barbara (Arnold)." Also other records.

Not *Venericardia ventricosa* Gould, Proc. Boston Soc. Nat. Hist., Vol. 3, p. 276, July 1850. "Hab. Puget Sound."

Type specimen. — "not known to be extant" (Woodring, 1946).

Type locality. — "Occurs with the preceding" [that is] "Locality. — California." In 1857 cited from "Santa Barbara, California."

Range. — Middle and late Pliocene and Pleistocene of southern California.

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 12096. L.A.M. 305A, 318, 323. S.D. 75, 124, 2359.

Original description (of *Cardita occidentalis*). — Subtriangular, equilateral; ventricose; ribs 15, rounded, wider than the interstices, and regularly granulated by transverse lines. (Conrad, 1855.)

"Allied to *C. _____*, of the San Pedro recent formation, but proportionally more elevated and having more prominent granules." (Conrad, 1855.)

Original description of *Cardita monilicosta*. — Shell nearly circular; beaks small, submedian, cardinal border straight or faintly arcuate. Surface marked by from fourteen to seventeen large rounded ribs, strongly moniliform; interspaces narrow, acute. Posterior muscular impressions largest. Pallial line broad and distinct but not impressed. Internal margin coarsely crenulate, one large square tooth, corresponding with each interspace between the ribs; extreme edge undulated. Hinge robust. Length, 0.19 in.; width, 0.2 in.; depth of single valve, 0.05 in. (Gabb, 1861.)

Remarks. — Three specimens with both valves and four single valves of a *Cyclocardia* collected by Henry Hemphill from the San Diego well are in the collections of the California Academy of Sciences. The largest specimen is 12.6 mm long, 11.4 mm high, convexity (both valves together), 9 mm. These have about 15 nodulose ribs. The original label cites "*Venericardia ventricosa* Gld. = *monilicosta* Gabb." A left valve in the collection of the University of California at Los Angeles from North Snyder School, Cabrillo Freeway, in San Diego, is 13.7 mm long, 14 mm high, convexity, 5.1 mm. Four very small single valves from Loc. 323 (LAM) are referable to this species.

The correct identification of these specimens is fraught with certain difficulties. For this reason the original descriptions of both *Cardita occidentalis* and *C. monilicosta* Gabb are included in the present work.

The specific name *occidentalis* appears to be the earliest name applicable to the present specimens. The description is applicable and the original illustration, although not satisfactory, has in general the outline and the sculpture similar to that of the present specimens.

The later name *Cardita monilicosta* Gabb, also based on specimens from Santa Barbara, has been relegated to the synonymy of *C. occidentalis* by various authors. Judging from the description, this appears to be the logical course.

The present specimens agree almost exactly with the illustration given by Arnold of a specimen from beds of Pleistocene age at Santa Barbara, California, under the name *Venericardia monilicosta* Gabb. This is certainly

referable to the same species illustrated by Woodring, Bramlette, and Kew (612) under the name of *Cardita* aff. *C. occidentalis* Conrad from Pleistocene beds at San Pedro, California, shown on their plate 33, figure 4. The specimens illustrated under the same name on their plate 31, figures 9 and 10, are more elongately rounded in outline and with flatter, less nodose ribs, and bear a resemblance to the *C. ventricosa* series discussed by Smith and Gordon (613). Quayle (614) believed that *C. occidentalis* and *C. monilicosta* are separable, basing his conclusions upon measurements of specimens.

Willett (615) mentioned the probable identity of *C. occidentalis* with *C. monilicosta* and he also mentioned a resemblance to *C. stearnsii* Dall (616), which, however, is a distinct species living in Puget Sound. Woodring, Bramlette, and Kew, (1946, p. 85) pointed out that the nodulose specimen illustrated on their plate 33, figure 4 bears a resemblance to *C. californica* Dall (617). The latter species does bear a general resemblance to *C. occidentalis* but is more narrowly trigonal in outline and the ribs, about 14-16 in number, are very coarsely nodulose and the shell is larger and quite thick.

A study of the small specimen, upon which the senior author based the record (618) of *Venericardia californica* Dall from the San Diego formation, reveals that it can be referred to *C. occidentalis*.

Fossils described under the name of *Cardita monilicosta* Gabb var. *ochotica* Slodkewitsch (619) from the Kavran Series of Pliocene age in western Kamtschatka, resemble Gabb's species in general characters but are said to possess 21-23 radial ribs and the outline of the shell was said to be more rounded. Perhaps this is the form cited by Tikonovich (620) from beds of Pliocene age on the Schmidt Peninsula, Sakhalin Island. According to Slodkewitsch, typical *C. monilicosta* Gabb was not found by him among the collections from Sakhalin or Kamtschatka.

Cyclocardia ventricosa Gould

Plate 43, Figures 3, 8

Cardita ventricosa Gould, Proc. Boston Soc. Nat. Hist., Vol. 3, p. 276, July, 1850. — Gould, U. S. Explor. Exped., Vol. 12, p. 417, 1852, Atlas, p. 14, pl. 36, figs. 532, 532a, 1856. — Gould, Otia Conch., pp. 83, 246, 1862. "Hab. Puget Sound." — A. G. Smith and Gordon, Proc. Calif. Acad. Sci., Ser. 4, Vol. 26, No. 8, pp. 214, 215, figs. 4A, B, 1948. "Puget Sound." Recent.

Venericardia ventricosa Gould, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 174, 182, 1912. "San Diego-Purisima." — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 36, pl. 3, fig. 8, 1924. Puget Sound. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 114, 1924. "Range. Belkoffski Bay, Alaska, to the Coronado Islands and Cortez Bank."

Type specimen. — Syntypes No. 3373, United States National Museum; also Syntype No. 216813, Museum of Comparative Zoölogy, Harvard University (Johnson, U. S. Nat. Mus., Bull. 239, p. 165, 1964).

Type locality. — "Hab. Puget Sound."

Range. — Middle Pliocene to Recent. Recent from Belkoffski Bay, Alaska, to the Coronado Islands and Cortez Bank, Mexico, in 37 to 272 meters (20 to 149 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A.

Original description. — Testa solida, ventricosa, ovato-trigona vix obliqua, radiatim 18-20 costata, costis concentricè subnodosis, interstitiis angustis, epidermide fuliginoso, villosa induta; umbonibus submedianis, obtusis; intus alba; margine profundè crenulato; dente cardinali valvae dextrae, elevato, crasso, triangulari. Lat. 3/4; alt. 5/8; lat. 1/2 poll. (Gould).

Compared with *C. borealis*, Conr., it is thicker, less transverse, more tumid at the beaks, which are less recurved; the ribs are barred; the cardinal tooth is short, triangular (not long falcate) and detached from the margin; the crenulations of the margin deeper. (Gould.)

Remarks. — The largest of four single valves from Loc. 305 (LAM) is a left valve 16.2 mm long and 15 mm high. There are 18 radial ribs of which the posterior 5 or 6 are smaller than the others. This valve as well as the smaller ones, compares favorably with Recent specimens of *Cyclocardia ventricosa* from Puget Sound and California.

So far as we can ascertain, most of the earlier records of this species from the San Diego Formation were based upon Dall's record (1874) which is referable to *Cyclocardia occidentalis* Conrad. The shell of *C. ventricosa* is more elongately (anterior-posterior) rounded and is sculptured with 18 to 20 rather than 14 to 17 radial ribs.

A Recent form from Monterey, California, more elongate (anterior-posterior) than usual for this species was named *C. ventricosa montereyensis* (621) by A. G. Smith and Gordon. Inspection of a large series of specimens of this subspecies reveals that there are forms which imperceptibly grade into typical *C. ventricosa*.

A small southern form, more rounded in outline and more inflated, with more sharply defined ribs, was described as *C. ventricosa redondocensis* by J. Q. Burch (622).

Wood (623) mentioned a close resemblance of *Cardita scalaris* in the Coralline and Red Crag of England to *C. ventricosa*. However, his description of the Crag fossil calls for 20 to 22 radial ribs and his figure suggests a more trigonal shell.

Cyclocardia inflata Hayasaka and Uozumi (624), described from beds of late Oligocene or early Miocene age in Japan, was said to be more rounded in outline and the umbo lower than that of *C. ventricosa*.

Barnard and Ziesenhenné (625) mentioned the occurrence of 132 specimens of *Cyclocardia ventricosa* per square meter on an "Amphiodia-Cardita" bottom off southern California.

Viviparity in this and other species of the Carditidae was discussed by Jones (626). A detailed discussion of *C. ventricosa* was published recently by Yonge (Proc. Malacol. Soc. London, Vol. 38, Pt. 6, pp. 494-505, figs. 1-9, 19, 24a, December, 1969).

GENUS *GLANS* MERGERLE VON MÜHLFELD

Glans Megerle von Mühlfeld, Mag. Gesell. Naturfor. Freunde zu Berlin, year 5, p. 68, 1811. Sole species, *Glans trapezia* Linnaeus. — Lamy, Jour. de. Conchyl., Vol. 66, No. 3, p. 222, 1922. "Type: *C. trapezia* Linné." — Palmer, Geol. Soc. Amer., Mem. 76, p. 82, 1958. "Type species by monotypy *Glans trapezia* (Linnaeus)."

Type species (by monotypy). — *Glans trapezia* Linnaeus [= *Chama trapezia* Linnaeus, Syst. Nat., ed. 12, p. 1138, 1767. "Habitat in Oceano Norvegico." Illustrated by Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 6, p. 231, pl. 38, figs. 21-25, 1892. — Dollfus and Dautzenberg, Mém. Soc. Géol. France, Paléo., Vol. 16, Fasc. 2, Mém. No. 27, p. 292, pl. 12 (Mém. pl. 20), figs. 16-23, 1909 [as *Cardita (Glans) trapezia*]. Aquitanian, Miocene to Recent. Does not occur in Norway (p. 294). — Cossmann and Peyrot, Act. Soc. Linn. Bordeaux, Vol. 66 (Conch. Néog. de l'Aquitaine, Vol. 2, Livr. 1), p. 31, figure of hinge, 1912.]

Range. — Paleocene to Recent. Recent from the intertidal zone to 91 meters (50 fathoms).

Description. — Shell bearing a general resemblance to carditids such as *Carditamera* but small, subquadrate in outline; hinge with well developed anterior and posterior laterals.

Remarks. — This genus is represented by one species, occurring both as a fossil and Recent, in western United States. *Cardita naviformis* Reeve (627), which lives in waters off the coast of Chile, also has been assigned to this genus.

Paraglans Chavan (628) was proposed as a subgenus to include a number of Eocene species formerly placed in the genus *Glans*.

Glans subquadrata Carpenter
Plate 43, Figures 16, 18, 19, 22, 30

Lazaria subquadrata Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 536, 627, 642, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 22, 113, 128, 1872. — Carpenter, Ann. Mag. Nat. Hist., Ser. 3, Vol. 15, p. 178, 1865. Reprint, 1872, p. 280. "Hab. Sta. Barbara (Jewett); Monterey, and along the coast to S. Pedro (State Coll. no. 403) (Cooper)."

Cardita (Carditamera) subquadrata Carpenter, Dall, Proc. Acad. Nat. Sci. Philadelphia, Vol. 54, Pt. 4, p. 707, 1902. Queen Charlotte Islands, Canada, to Todos Santos Bay, Lower California.

Not *Cardita subquadrata* Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 3, p. 298, 1847. "Eocene rocks in St. Matthew's Parish, Orangeburg District, S. D."

Not *Cardita subquadrata* Gabb, Jour. Acad. Nat. Sci. Philadelphia, Ser. 2, Vol. 4, p. 303, pl. 48, figs. 22a, 22b [indicated as 21a, 21b on plate], March, 1860. New Jersey, Cretaceous.

C[ardita]. (Carditamera) carpenteri Lamy, Jour. de Conchyl., Vol. 66, No. 3, p. 264, June 20, 1922. New name for *Lazaria subquadrata* Carpenter.

Glans minuscula Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 277, pl. 13, figs. 10a, 10b, November 3, 1931. Pleistocene and Recent. New name for *Lazaria subquadrata* Carpenter.

Glans subquadrata Carpenter, K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 82, pl. 7, figs. 1-4 (syntypes), 1958. Earlier records cited.

Type specimen. — Syntypes in United States National Museum, No. 15681 (Palmer, 1958).

Type locality. — "Recent. Monterey, California (type)" (Palmer, 1958). Several localities originally indicated by Carpenter, including "Neighbourhood of Mont-

erey." "Neighbourhood of Sta. Barbara." "Vancouver Island, Straits of S. Juan de Fuca, and adjoining shore of Washington Territory . . ."

Range. — Middle Pliocene to Recent. Recent from Queen Charlotte Islands, British Columbia, to Todos Santos Bay, Lower California, from intertidal zone to 91 meters (50 fathoms). Usually in shallow marine waters, attached to the underside of stones or other objects.

Occurrence in San Diego Fm. — L.A.M. 305, 305A.

Original description. — "Hinge of *Lazaria*: outside like *Cardita variegata*, jun." (Carpenter, 1864).

L. testa extus *Carditae variegatae* jun. simili; pallida, castaneo tincta; subquadrata, antice truncata, subregulariter ventricosa, dorsalter tumida; costis radiantibus circ. xiv-xvi., tumidis, nodosis, diagonalibus majoribus; interstitiis plus minusve insculptis: intus, valva dextra dente cardinali triangulari, inter duas fossas sito, haud elongato; dent. lat. a cardine separatis, ant. extante, post. obsoleto, calloso: v. sinistrali dent. card. ii. angustis, subaequalibus, radiantibus; lat. ant. et post. extantibus: cicatr. adduct. subrotundatis. Long. .37, lat. .25, alt. .34. (Carpenter, 1865.)

The outside of this remarkable little species is typically carditoid; the hinge is intermediate between *Lazaria* and *Cypricardia*. (Carpenter, 1865.)

Remarks. — A number of single valves of this species, the largest one 5.8 mm long, was collected by G. P. Kanakoff near the Mexican boundary. The shell characters of these are identical with those of Recent specimens from adjacent waters.

Lamy, and later Grant and Gale, placed *Lazaria subquadrata* Carpenter in the genus *Cardita*. They therefore proposed a new specific name for Carpenter's species because of the prior *Cardita subquadrata* Conrad, 1847, and of Gabb, 1860. Woodring, Bramlette, and Kew (629), and later Palmer, pointed out that if Carpenter's species is not referable to the genus *Cardita* or if the species described by Conrad and by Gabb are not assigned to the genus *Glans* then a new name is not necessary for *Lazaria subquadrata*. According to Woodring, Bramlette, and Kew, "it is improbable that either Conrad's or Gabb's *Cardita subquadrata* is to be assigned to *Glans*."

The only other reported occurrence of *Glans subquadrata* in beds of undoubted Pliocene age is in the Cebada Member of the Careaga Sandstone in the Santa Maria district.

Orcutt (630) reported *Cardita subquadrata* from strata of "Tertiary" age at Pacific Beach but his query "?Pleist." leads us to omit assignment of his record to the San Diego Formation.

A detailed discussion of this species was published recently by Yonge (Proc. Malacol. Soc. London, Vol. 38, Pt. 6, pp. 505-509, figs. 10-13, 20-22, 1969).

GENUS MIODONTISCUS DALL

Miodon Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 611, 627, 642, 682, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 97, 113, 128, 168, 1872. Species originally cited: "*Miodon prolongatus*"; "*Astarte orbicularis*, J. Sby."; "*Cardita corbis*." — Dall, Proc. Acad. Nat. Sci. Philadelphia, Vol. 54, Pt. 4, p. 700, January 20, 1903. "Type *M. prolongatus* Carpenter."

Not *Miodon* Duméril, 1859; not *Miodon* Sandberger, 1870. *Miodontiscus* Dall, Nautilus, Vol. 16, No. 12, p. 143, April, 1903. A new name for *Miodon* Carpenter, 1864, not *Miodon* Duméril, 1859, nor *Miodon* Sandberger, 1870. — Lamy, Jour. De Conchyl., Vol. 66, No. 4, p. 293, 1922. "type: *V. prolongata* Cpr." — K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 83, 1958. "Type species by original designation *M. prolongatus* Carpenter."

Type species (by subsequent designation, Dall, 1903): "Type *M. prolongatus* Carpenter." [The use of "n. subg. n. s." by Carpenter (1864, p. 627), is considered by K. V. W. Palmer, 1958, to be an original designation of *M. prolongatus* as type species.]

Range. — Miocene to Recent. Recent in from 9 to 128 meters (5 to 70 fathoms).

Description (of *Miodon* Carpenter). — Shell ovately subtrigonal, small, solid, ventrally much produced, with the umbones situated anteriorly, radiately ribbed, the ribs being partially intersected by concentric sulcations; hinge in the right valve with one posterior cardinal and one anterior lateral tooth, left valve with one triangular anterior and one elongated posterior cardinal, and a very small anterior lateral tooth. Closely allied to *Pleuromeris*. (Tryon, G. W., Jr., Structural and Systematic Conchology, Vol. 3, p. 233, 1884.)

Remarks. — Dall, 1903, mentioned that this genus is similar to *Pteromeris* Conrad (631) "but not compressed, and with the posterior (instead of the anterior) right cardinal absent and a posterior right and anterior left lateral developed feebly."

Iredale (632) believed *Miodontiscus* to be a synonym of *Coripia* De Gregorio (633) but Dall and most later authors consider *Coripia* to be a synonym of *Pteromeris*.

Miodontiscus has been reported from beds of Miocene age in Japan but up to the present time it has not been recorded earlier than middle Pliocene in western North America.

Miodontiscus prolongatus Carpenter

Plate 56, Figures 1-5

Miodon prolongatus Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 611, 627, 642, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 97, 113, 128, 1872. P. 97 "(Neeah Bay, Swan)", p. 128, indicated as from "Vancouver Island, Straits of S. Juan de Fuca, and adjoining shores of Washington Territory . . ." — Carpenter, Ann. Mag. Nat. Hist., Ser. 3, Vol. 14, p. 424, December, 1864. Reprint in Smithsonian Misc. Coll., No. 272, p. 236, 1872. "from Vancouver District." — Stearns, Proc. U. S. Nat. Mus., Vol. 13, No. 813, p. 217, pl. 16, figs. 7, 9, 1890. "from Neeah Bay, and Mr. Dall obtained several examples in the Alaskan region at Middleton Island." [Figured specimen from Middleton Island.]

Venericardia (*Miodontiscus*) *prolongata* Carpenter, I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 36, pl. 16, figs. 5, 6, March, 1924. Middleton Island, Alaska, to San Diego, California. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 115, pl. 2, figs. 5, 6, 1924 (as *Venericardia prolongata*). [Same illustrations and range as in preceding reference.]

Cardita (*Miodontiscus*) *prolongata* Carpenter, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 276,

1931. Pleistocene to Recent.

Miodontiscus prolongatus Carpenter, Chavan, Compt. Rend. Sci. Soc. Géol. France, No. 10, p. 122, 1937. — K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 83, pl. 8, figs. 1-7, 1958. Earlier records cited. Syntype illustrated.

Type specimens. — "Syntypes. — U. S. National Museum, no. 15472; Redpath Museum, no. 2377" (K. V. W. Palmer, 1958).

Type locality. — "Neah Bay, Washington (type)" (Palmer).

Range. — Middle Pliocene to Recent. Recent from Middleton Island, Alaska, to San Diego, California, in 9 to 55 meters (5 to 30 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 309, 323.

Original description. — "Outside Lucinoid; hinge and scars nearer to *Venericardia*. Congeneric with *Astarte orbicularis*, J. Sby. Min. Conch. pl. 444, f. 2, 3 (non ejusdem, pl. 520, f. 2). G. Oolite; and with the Crag *Cardita corbis*." (Carpenter, August, 1864.)

Supplementary description: *M. testa parva, solida, tumida, compacta, albida; ventraliter antice valde prolongata, excurvata; lunula longa, rectiore, haud impressa; umbonibus antice inflectis, obtusis, valde prominentibus; margine dorsali postico parum excurvato; costis radiantibus, x.-xii. latis, obtusis, marginem attingentibus, parum expressis, dorsaliter obsoletis, a liris incrementi concentricis, plus minusve distantibus, expressis, hic et illic interruptis: intus, margine a costis plus minusve obsoletim crenulato; cardine dentibus v. dextr., uno postico, inter duas fossas elongato, et. lat. ant. lunulari; v. sinistr., dent. ant. triangulari, post. valde elongato, lat. ant. minimo, obsoleto; cicatr. add. subrotundatis, ventraliter sitis. Long. .23, lat. .24, alt. .16. (Carpenter, December, 1864, p. 424.)*

Remarks. — Typical specimens of *Miodontiscus prolongatus* are about 5 mm in length and in height. They are trigonally subcircular in outline with rather prominent, erect beaks which are slightly curved anteriorly. The external sculpture consists of broad, low, radiating ribs and widely spaced concentric, incised lines.

About 20 single valves in the present collection are referable to *Miodontiscus prolongatus*. The largest one, a left valve (ventral margin imperfect), is 7.9 mm high and 6.8 mm wide. Some of the valves are considerably eroded but the observable shell characters agree well with Recent specimens of Carpenter's species.

Woodring (634) reported comparable specimens from the Cebada and Graciosa members of the Careaga Formation in Santa Barbara Co. He considered *Venericardia yatesi* Arnold (635) to be a synonym of *M. prolongatus*.

Carpenter's description of *M. prolongatus* calls for 10 to 12 radiating ribs and the illustrations by Palmer show about this number. Arnold's description of *Venericardia yatesi* calls for 8 to 9 radial ribs. We have not studied a series of Arnold's species and can offer no opinion as to its identity with *M. prolongatus*, but it seems likely that variation in the species may be sufficient to justify placing it in the synonymy of Carpenter's species.

Slodkewitsch (636) reported *M. prolongatus* from beds of late Tertiary age in western Kamtschatka as did Pleshakov (637). However, according to Slodkewitsch,

his specimens are sculptured with 18 to 21 radial ribs. Those specimens, no doubt, are referable to some other species.

Cardita (*Miodontiscus*) *nakamurai annakensis* Oinomikado (638) described from the late Tertiary of Japan was compared by its author with *M. prolongatus*.

GENUS *MILNERIA* DALL

Ceropsis Dall, Amer. Jour. Conch., Vol. 7, Pt. 2, p. 152, November 2, 1871.

Not *Ceropsis* Gay and Solier, 1839. Coleoptera.

Milneria Dall, Amer. Nat., Vol. 15, No. 9, p. 718, September, 1881. A new name for *Ceropsis* Dall, 1871, not *Ceropsis* Gay and Solier, 1839. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1411, October, 1903. "Type *Ceropsis minima* Dall, 1871." — Lamy, Jour. de Conchyl., Vol. 81, No. 4, p. 299, 1937.

Type species (by original designation). — "Type *Ceropsis minima*, n. s."

Range. — Middle Pliocene to Recent. Recent from Monterey, California, to Punta Abreojos, Lower California, and Guadalupe Island, from the intertidal zone to 27 meters (15 fathoms).

Description. — Shell with two left and three right cardinals, the posterior left lateral, posterior and anterior right cardinals minute and hardly recognizable except in very well-developed specimens, in which the formula is

$$\frac{L. 1.01010.}{R. 0.10101.}$$

The female has a dome-like indentation rising from the ventral margin of the valves, which is closed only by an extension of the mantle edge and therefore not included within the shut valves. The animal is minute, byssiferous, and a nestler on flat surfaces, like the backs of the shells of *Haliotis*. (Dall, 1903).

Remarks. — This genus is dioecious. The young are incubated in a fold in the mantle until they pass the prodissoconch stage.

This is the first record of the occurrence of *Milneria* in the San Diego Formation. The genus was reported by Vedder (639) from strata of late Pliocene age in the Los Angeles basin. It also was reported by Woodring from beds of Pleistocene age in the Palos Verdes Hills, San Pedro, California.

Milneria minima Dall
Plate 43, Figures 1, 2, 14

Ceropsis minima Dall, Amer. Jour. Conch., Vol. 7, Pt. 2, p. 152, pl. 16, figs. 5, 6, November 2, 1871.

Milneria minima Dall, Lamy, Jour. de Conchyl., Vol. 66, No. 4, p. 353, fig. (p. 352), 1922. San Diego, California. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 117, pl. 54, figs. 29, 30, 31, 1924. "Monterey, California, to Rosario Bay, Lower California." — Lamy, Jour. de Conchyl., Vol. 81, No. 4, p. 299, fig. 9 (1, 2), 1937. — Franc, Traité de Zool., Tom. 5, Fasc. 2, p. 2095, fig. 1774, 1960. "de California."

Type specimen. — No. 63349, United States National Museum.

Type locality. — "Habitat, nestling or burrowing in *Haliotis rufescens*, at Monterey, also dead on beach, Dall; nestling under stones at low water, Canfield, Stearns, and Cooper."

Range. — Middle Pliocene to Recent. Recent from Monterey, California, to San Geronimo Island, near Rosario Bay, Lower California, Mexico, from the intertidal zone to a depth of 27 meters (15 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305.

Original description. — Shell minute, trapeziform, white, with a thin brownish epidermis. Umbones prominent, nearly terminal. Anterior margin rather strongly angulated; basal margin straight, or a little concave; lower posterior extremity angulated; upper posterior angle rounded off; posterior margin rather oblique. Hinge line smooth, rather broad. Ligament conspicuous, moderately long. A rounded carina passes from the umbo to the lower posterior angle, above which are from two to five radiating ribs. General sculpture of sharp elevated lines of growth, which become vaulted scales on the ribs. Margin lightly crenulated. Interior polished; muscular and pallial impressions indistinct. Long. 14, lat. .08, alt. .175 in. (Dall.)

Remarks. — Three valves of this species are present in the collection from Loc. 305 (LAM). One of these, a well preserved right valve, is 5 mm long.

This is the first record of *Milneria minima* in beds of Pliocene age but it was reported by Vedder (640) from a terrace of Pleistocene age on San Nicolas Island, California.

Woodring reported the occurrence of *Milneria kelseyi* Dall (641) from beds of Pleistocene age in the Palos Verdes Hills, San Pedro, as did Chace, 1966, and Vedder (1960) reported "*Milneria* cf. *M. kelseyi*" from strata of Pliocene age in the Los Angeles basin, California. That species in some cases has been confused with *M. minima*. The major radial ribs on *M. minima* are rather coarse and are about equal in size, whereas those on *M. kelseyi* are finer and less coarsely scaled. The umbonal and one or more of the other ribs, are higher than the rest. Furthermore the lunule of *M. kelseyi* is smaller and the escutcheon larger than that of *M. minima*. *Milneria kelseyi* attains a greater size than *M. minima*, up to 8 mm long, and is said to be the one more commonly found under rocks along the seashore.

SUPERFAMILY LEPTONACEA GRAY (642)

Remarks. — Most of the members of this superfamily possess small, thin shells, and often nestle in crevices, in holes in rocks, or in empty shells. Such habitat often results in distortion and variability in shape of the shells. Some forms live symbiotic with other invertebrates such as echinoderms, sponges, and crustacea. The exact relationships of the members of this superfamily are unknown.

Dall (643) published a synopsis of the Recent and Tertiary Leptonacea of North America and Laserson (644) recently presented a revision of the Leptonidae of New South Wales, Australia.

Some authors have included this group of mollusks under the Erycinacea and Erycinidae (645). However,

Swainson (646) in 1832-1833 used the family name Erycinidae in the phylum Insecta. Later Wood (647) included many of the genera of these small mollusks in the Fragillidae. Until the higher categories of molluscan nomenclature are more stabilized, it seems best to include this group under the well known superfamily name Lep-tonacea.

Chavan (648) recently discussed the hinge characters of the superfamily "Erycinacea." He placed the following six families under this category: Erycinidae, Kelliidae, Leptonidae, Montacutidae, Galeommatidae, Kelleyellidae.

A paper by Popham (649) contains the results of a study of the mantle cavities of some members of this superfamily, and a publication by Oldfield (650) deals with their reproduction and development. Boss (651) recently discussed the symbiotic habits of this group of small bivalves.

In the present paper we have assigned as members of the Leptonacea, the families Kelliidae and Montacutidae. Clark, the author of those families considered the well known genus *Lepton* Turton (652) to be quite distinct from the genera included in those groups.

FAMILY KELLIIDAE FORBES AND HANLEY (653)

Shell small, ovate or obicular, thin, convex, white or subtranslucent, the umbones and beaks submedian or anterior. Surface smooth and often glossy, occasionally punctate or partially radially ribbed; external ligament small, the internal resilium attached to a posteriorly directed oblique groove; hinge with one or two cardinal teeth and, usually one or two posterior lateral teeth in each valve, but lacking in some genera; pallial line simple; surface of exterior sometimes covered by the mantle. (Adapted in greater part from Olsson, Mollusks of the Tropical Eastern Pacific, Paleo. Res. Inst.: Ithaca, New York, p. 231, 1961.) Paleocene to Recent.

GENUS ALIGENA LEA

Aligena H. C. Lea, Proc. Amer. Philos. Soc., Vol. 3, p. 163 September, 1843. *Aligena striata* and *A. laevis* mentioned but without description or illustration. — H. C. Lea, Trans. Amer. Philos. Soc., New Ser., Vol. 9, p. 238, December, 1846. *Aligena striata* and *A. laevis* described and illustrated. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1175, 1900. "Type, *A.*

striata Lea." — Gardner, U. S. G. S., Prof. Paper 199A, p. 87, 1943. Type as designated by Dall. — Harry, Veliger, Vol. 11, No. 3, p. 164, 1969. Earlier designations cited.

Type species (by subsequent designation, Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1175, 1900). — *Aligena striata* H. C. Lea, Trans. Amer. Philos. Soc., Ser. 2, Vol. 9, p. 238, pl. 34, fig. 13, December, 1846. "From the Tertiary of Petersburg, Virginia." Dall (Proc. U. S. Nat. Mus., Vol. 21, No. 1177, p. 877, 1899) cited *Abra aequata* Conrad as the "typical species" of *Aligena* but that species was not included with the taxa originally referred to *Aligena* by Lea. Later, Dall placed *Aligena striata* Lea in the synonymy of *Aligena aequata* (= *Amphidesma aequata* Conrad, 1843). See Dall, 1900, p. 1175, pl. 24, figs. 8, 8a, 8b. Miocene of southeast Atlantic states, also Caloosahatchie Pliocene of Florida.

Range. — Miocene to Recent. Recent in temperate and tropical waters, usually from low tidal zone to 112 meters (61 fathoms). One species was reported by Dall from 3680 meters (2012 fathoms).

Description. — The characteristic of this group is the possession of a rounded triangular inflated shell with only a single small anterior tooth under the beaks, separated by a gap from the surface of attachment, under the posterior dorsal margin, of an elongate internal resilium carrying a lithodesma. The pallial line is simple, and the cardinal of the left valve more feeble than the other. (Dall, 1900.)

Remarks. — *Aligena* is here recorded for the first time from beds of Pliocene age in the west American states. This genus is well known in beds of Miocene age in the Atlantic states and has been reported from the Vienna and Paris basins.

Four Recent species referable to *Aligena* have been described from west American waters two of which have been reported from beds of Pleistocene age.

Dall (1900, p. 1175) believed that a close relationship existed between *Aligena* and *Spaniodon* Reuss (654), but Cossmann and Peyrot (655) believed it to be close to *Spaniorinus* Dall (656).

Harry (657) recently reviewed the living species of *Aligena*. He mentioned that some species of this genus are probably polychaete associates.

Aligena diegoana n. sp.

Plate 44, Figures 1, 6;

Plate 45, Figures 6, 7, 10, 11, 13

Description. — Shell roundly quadrangular, rather large for the genus, convex, the anterior is longer and

Key to Genera and Subgenera of Kelliidae

- | | |
|--|--|
| A. Left valve with 1 cardinal tooth;
lateral teeth lacking <i>Aligena</i> | aa. Valves radiately striated or
punctate; periostracum lacking |
| B. Left valve with 2 cardinal teeth;
lateral teeth present | b. Ventral margin of hinge plate
bisected by the resilium <i>Bornia</i> |
| a. Valves smooth; periostracum
present <i>Kellia</i> | bb. Ventral margin of hinge plate
not bisected by the resilium. . . <i>Temblornia</i> |

narrower than the posterior end; beaks small, prosogyrate, situated a little posterior to the middle of the valves; lunular area gently depressed; anterior dorsal margin sloping moderately steeply to the anterior and which is rounded and slightly attenuated, posterior dorsal margin sloping gently downward and merging imperceptibly into the broadly rounded posterior end, ventral margin very slightly rounded; exterior of valves sculptured only with lines of growth; hinge of right valve with a large, slightly twisted tooth beneath the beak, behind this a subtriangular, elongated ligamental pit; in front of the tooth there is an elongated depression which receives a projection of the opposite valve and fades out as a slight groove along the margin; hinge of left valve (paratype) with a large, tooth-like projection of the lunular margin, behind this a very small cardinal lamella (lacking on some specimens) below the beak, and back of this the ligamental pit. Dimensions of holotype, a right valve, length 7.9 mm, height 6.1 mm, convexity (one valve), (approximately) 2 mm.

Type Specimen. — Holotype and paratypes in Los Angeles County Museum. From Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U. S. G. S. topog. map, San Ysidro quad., ed. 1943).

Occurrence in San Diego Fm. — L.A.M. 305A, 318, 319.

Remarks. — This species is represented in the present collections by more than 30 single valves. These vary in outline, some are more rounded in outline than others, and in some specimens the ventral margin is nearly straight. A broad, low, medial sulcus is present on some valves.

The cardinal tooth in the left valve of *A. diegoana*, n. sp., is reduced to a thin lamella, or is absent on some specimens. The development of a tooth-like projection of the lunular margin which fits into a groove on the opposite valve appears to be compensatory for the reduction of the cardinal and augments the interlocking of the hinge area.

The general outline of *Aligena diegoana*, n. sp., is somewhat similar to that shown in an illustration of a Recent specimen from off the west coast of Lower California which Harry (1969, fig. 16) referred to *Aligena cerritensis* Arnold. The type specimen of *A. cerritensis* is obliquely ovoid in outline.

The general shape of some valves of the new species is similar to that of *Aligena aequata* var. *nuda* Dall from Miocene strata in Maryland, as illustrated by Glen (658). The new species also bears a resemblance to the east American *Aligena laevis* H. C. Lea (659) which occurs in strata of Miocene and Pliocene age. The west American species is more quadrate in outline and the hinge of the right valve apparently has a deeper, more trigonal ligamental pit.

The species described as *Aligena redondoensis* by T. Burch (660) was placed by Harry (1969, p. 179, figs. 34-37) in a new genus *Tomburchus* and assigned to the family Thyasiridae.

A species from British Columbia was described as *Aligena (Odontogena) borealis* by Cowan (661). This boreal species is the type of *Odontogena* to which Harry (1969, p. 179) assigned generic rank.

GENUS *KELLIA* TURTON

Kellia Turton, *Conchylia Insularum Britannicarum*, pp. XIX, XXV, 56, 1822. Species cited, *Kellia suborbicularis* Montagu, *Cardium rubrum* Montagu and *Cardium laeve* Walker (in synon.) — Jeffreys, *Brit. Conch.*, Vol. 2, p. 222, 1863. — Kobelt, *Illustr. Conchyliebuch*, Bd. 2, Lief. 10-11, p. 351, 1881. "Typus is *Kellia suborbicularis* Montagu (Taf. 103, Fig. 3) aus den europäischen Meeren." — K. V. W. Palmer, *Geol. Soc. Amer.*, Mem. 76, p. 87, 1958. "Type species by subsequent designation, Reclúz". . . , 1844. — Olsson, *Mollusks of the Tropical Eastern Pacific*, (Paleo. Res. Inst., Ithaca, New York), p. 231, 1961. Type species as designated by Reclúz.

Chironia Deshayes, *Rev. Zool. par la Soc. Cuvierienne*, Ann. 1839, p. 357. Sole species, "*Chironia Laperousii*."

Kellyia Turton (emend.), Bucquoy, Dautzenberg, and Dollfus, *Moll. Mar. du Roussillon*, Tome 2, Fasc. 6 (Pelecypoda, Fasc. 19), p. 235, 1892. "Il faut donc que le *Mya suborbicularis* soit conservé comme type du genre *Kellyia*."

Kellya Turton, Thiele, *Handbuch Syst. Weichtierkunde*, Bd. 2, p. 870, 1934. [Not all the synonymy.]

Type species (by subsequent designation, Reclúz, *Rev. Zool.*, Soc. Cuvierienne, Vol. 7, p. 295, 1844). — "Le type de son *Kellia*, celui seul qui correspond au caractère de son genre, le *Kellia suborbicularis* . . ." [= *Mya suborbicularis* Montagu, *Test. Britannica*, Pt. 1, p. 39, 1803. "We first discovered this species in hard limestone at Plymouth." "It is sometimes dredged up in Salcomb-bay." Illustrated in *Suppl.*, pl. 26, fig. 6, 1808. — Turton, *Conch. Ins. Brit.*, p. 57, p. 11, figs. 5, 6, 1822 (as *Kellia suborbicularis*). "In limestone and old bivalves." — Forbes and Hanley, *Hist. Brit. Moll.*, Vol. 1, pl. 0, fig. 4 (animal), 1853; Vol. 2, p. 87, pl. 18, figs. 9, 9a, 9b, 1853 (as *Kellia suborbicularis*). Loire basin, France, middle Miocene. — Tebble, *British Bivalve Seashells* [British Museum (Nat. Hist.)], p. 83, text fig. 37a, b, c, 1966 (as *Kellia suborbicularis*.)

Range. — Eocene to Recent. Recent, widespread in all seas from intertidal zone to 2772 meters (1515 fathoms).

Description. — Shell small or of medium size, thin, glassy, white, suborbicular and strongly convex, surface usually smooth, polished or with fine or strong, concentric lines of growth. The umbones are prominent, submedian, the small beaks incurved and prosogyrous. Hinge plate narrow, with a wide notch in the middle bordered on each side by a small tooth, the anterior one shaped like a cardinal tooth, the posterior one placed more distantly; the left valve has two small divergent cardinal teeth with a socket or pit between them, the right valve has a single cardinal only; both valves have a flattened tooth at the posterior end of the median pit. Ligament is wholly internal, the tensilium small, narrow, lying below the margin and above a narrow nymphal lamina which distantly ends in a tooth, the resilium also elongated in form and attached to a linear groove in the roof of the subumbonal cavity. In some species, the surface is covered by a glossy, yellowish periostracum. (Olsson, *Mollusks of the Tropical Eastern Pacific*. Paleo. Res. Inst.: Ithaca, New York, p. 231, 1961.)

Remarks. — There have been differences of opinion

by various authors (662) concerning the spelling of this generic name but most authors adhere to the original orthography, *Kellia*.

The members of *Kellia* often nestle in holes in rock or in pilings. Some species attain a length of 33 mm (663) but most of them are shorter. Oldfield (664) discussed the functional morphology of *K. suborbicularis*.

In western North America, three species referred to *Kellia* have been described from beds of Eocene age, one in the Oligocene, and two range from Pliocene to Recent. The genus is here reported from the San Diego Formation for the first time.

Kellia laperousii Deshayes
Plate 44, Figures 11, 19

Chironia laperousii Deshayes, Rev. Zool., Soc. Cuvierienne, Année 1839, p. 357, issued December, 1839. — Deshayes, Mag. de Zool., Ann. 1840, Livr. 5, Moll., pl. 12, 4 figs. — Chenu, Man. de Conchyl., Vol. 2, p. 126, figs. 600, 601, 1862.

Bornia laticola Valenciennes, Voy. Venus, Atlas, Moll., pl. 24, figs. 7, 7a, 7b, 1846. [No description nor locality.]

Kellia laperousii Deshayes, Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 643, issued August, 1864. Cited from several localities from Vancouver Island, British Columbia, to California. Reprint in Smithsonian Misc. Coll., No. 252, p. 129, 1872. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 137, pl. 18, figs. 1, 1a, 1903. Pliocene to Recent. San Pedro and San Diego, California, Pleistocene. — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 39, pl. 6, fig. 2; pl. 37, fig. 4, 1924. "Bering and Pribilof Islands, Bering Sea, to San Diego, Calif." — Yonge, Univ. Calif. Publ. Zool., Vol. 55, No. 11, pp. 451-453, fig. 1 (in text), 1951. — Morris, A Field Guide to Shells of the Pacific Coast and Hawaii. (Houghton Mifflin Co., Boston) p. 38, pl. 10, fig. 7, 1952. — Howard, Wasmann Jour. Biol., Vol. 11, No. 2, p. 238, fig. 3 (p. 237), 1953.

Kellia laperousei Deshayes, Fischer, Man. de Conchyl., Fasc. 11, p. 1026, pl. 19, fig. 11 ("Californie"), 1887.

Kellia laperousei Deshayes, I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 131, pl. 10, fig. 2; pl. 33, fig. 4, 1924. "Bering Sea and Pribilof Islands to San Diego, California." Also San Pedro, Pliocene; and San Pedro and San Diego, California, Pleistocene.

Chironia suborbicularis (Montagu) variety *laperousii* Deshayes, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 300, pl. 14, figs. 19a, 19b, 1931. [Not all the synonymy.] Pleistocene and Recent.

Type specimen. — Dr. André Franc informed us (written communication, October 22, 1964) that two valves labeled "Type" are in the collection of the Laboratoire de Malacologie, Muséum National d'Histoire Naturelle (Paris) but that it is uncertain whether or not these represent the type specimen.

Type locality. — No locality cited originally.

Range. — Middle Pliocene to Recent. Recent from Bering Sea and Pribilof Islands to Tiburon Island in the Gulf of California, from intertidal zone to 393 meters (215 fathoms).

Occurrence in San Diego Fm. — L.A.M. 107, 305, 305A.

Original description. — Testa ovato transversa, sub-equilaterali, inflato turgida, laevigata; alba sub-epidermide viridi lutescente, umbonibus minimis, acutis, oppositis. (Deshayes.)

Remarks. — Several valves here referred to *Kellia laperousii* are present in the collections of the Los Angeles County Museum from near the Mexican boundary. One of the largest of these is 8.5 mm long and 6.9 mm high. One very convex right valve from Loc. 107 (LAM), retaining most of the shell material, apparently the same species, is 17 mm long, 13.5 mm high, convexity, approximately 5 mm. These valves closely resemble Recent specimens, in various collections, identified with *K. laperousii*. A large Recent specimen in the collections of the California Academy of Sciences, collected by W. W. Schneeble in Monterey Bay, California, at a depth of 40 feet, is 31 mm long, 25 mm high, the convexity (both valves together) 29 mm.

This is the first record of the occurrence of this species in the San Diego Formation. It has been reported from beds of similar age, the Cebada Member of the Careaga Formation, in the Santa Maria district in Santa Barbara Co.

Some of the small valves, about 3 mm long, from near the Mexican boundary, bear a close resemblance to *K. suborbicularis* Montagu, originally described from England. However, there is so much variation in shape in a series of Recent specimens of *K. laperousii*, some elongated, some subcircular, that we assign all the fossil valves in the present collections to that species. Howard (1953) discussed the early stages of development of this species.

Kellia suborbicularis Montagu (665), reported to range from middle Miocene to Recent in Europe, has been reported from beds of Pliocene age in Los Angeles by Soper and Grant (666), by others from beds of Pleistocene age in southern California and in the Galápagos Islands. It was cited by Laws (667) as occurring in beds of Pleistocene age in New Zealand, and from beds of Pleistocene age from widespread areas such as Morocco, Patagonia and New Zealand. It has been reported living in nearly all temperate and tropical seas. Some authors have considered it to be a bipolar species. Marie Lebour discussed the life history of this species (see Jour. Mar. Biol. Assoc. U. K., Vol. 22, No. 2, pp. 447-451, text-fig. 1 (a-h, j-m), 1938).

The question as to whether this species is cosmopolitan or whether several closely related forms are involved has been discussed by several authors. E. A. Smith (668) stated that shells of this species could not be separated with certainty from allied forms. More recently Soot-Ryen (669), in a discussion of Antarctic shells similar to *K. suborbicularis*, stated that the relationship of such forms is still unsettled but he suggested that probably a number of nearly related species are concerned in this problem.

None of the fossils from the San Diego Formation is as circular in outline as the syntypes of the Recent west American *K. laperousii chironii* Carpenter illustrated by Palmer (670).

Kellia rotunda Carpenter was described as much larger than *K. suborbicularis* and nearly round in outline. The type of this species was not found by Palmer (671) and it generally has not been cited in recent years.

GENUS *BORNIA* PHILIPPI

Bornia Philippi, Enumeratio Molluscorum Siciliae, Vol. 1, p. 13, 1836. — Gardner, U. S. G. S., Prof. Paper 199-A, p. 82, 1943 [January, 1944]. Type as designated by Stoliczka. — Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 92, 1953. Type as designated by Stoliczka.

Type species (designated by Stoliczka, Mem. Geol. Surv. India, Paleo. Indica, Ser. 6, Vol. 3, Cretaceous Fauna of South India, Vol. 3, pp. XIX, 266, 1870). — "type, *B. corbuloides*, Phil." [*Bornia corbuloides* Philippi, 1836, p. 14, pl. 1, fig. 15. "Habitat Cataniae, Panormi, non rara." — Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 6 (Pelecypoda, Fasc. 19), p. 235, pl. 39, figs. 1, 2, 1892 (as *Kellyia sebetia* Costa; as of Cantraine on expl. to plate). Mediterranean and Adriatic; Portugal. Miocene to Recent. — Cossmann and Peyrot, Conch. Néogène l'Aquitaine, Vol. 1, Livr. 3 (extr. from Act. Soc. Linn. Bordeaux, Vol. 65), p. 569, fig. 109 (hinge of *Bornia sebetia*), 1911.]

Range. — Early Eocene to Recent.

Description. — Shell usually small, subtrigonal to subelliptical, compressed or weakly convex. Surface usually smooth, polished or faintly ribbed and striated. Ligament comprising a feeble external portion, more or less amphidetic and a subumbonal, internal resilium without a lithodesma. Hinge: left valve with a long, strong, posterior lateral tooth and a smaller, less distant anterior lateral, together with a small cardinal closely adjacent to it; in the right valve with strong lateral sockets and a small, anterior cardinal socket. (Olsson and Harbison.)

Remarks. — The shell of this genus differs from that of *Kellia* in that the surface is radially striate or punctate, at least in part, in lacking a periostracum, and in the narrower hinge in which the posterior cardinal of the left valve is greatly reduced in size.

Five Recent species assigned to *Bornia* have been described from the Panamic region and one from southern California.

SUBGENUS *TEMBLORNIA* KEEN

Temblornia Keen, Trans. San Diego Soc. Nat. Hist., Vol. 10, No. 2, p. 38, December 30, 1943.

Type species. — "Type: *Donax triangulata* Anderson and Martin, 1914." [Proc. Calif. Acad. Sci., Ser. 4, Vol. 4, p. 63, pl. 3, fig. 9, December 30, 1914 "... on west bank of a small canyon 1 1/4 miles northeast of Barker's ranch house, Kern County, California." Miocene. — Keen, 1943, p. 39, pl. 3, figs. 6, 7 (as *Bornia* (*Temblornia*) *triangulata*).

Range. — Middle Miocene to middle Pliocene.

Description. — Resembling *Bornia* in outline, with radial sculpture on anterior and posterior slopes; differing from *Bornia*, sensu stricto, in the structure of the hinge; resilifer small and shallow, ventral margin of hinge plate entire, not bisected as in *Bornia*, s. s., by the insertion of the resilium; hinge teeth well developed, consisting of two cardinals and a posterior lateral in the left valve, two cardinals in the right. (Keen.)

Remarks. — Keen called attention to the similarity of this subgenus to *Semeloidea* Bartram and Powell, which has as type *S. donaciformis* Bartram and Powell (Trans.

New Zealand Inst., Vol. 59, Pt. 1, p. 158, pl. 29, figs. 49, 50, 1928) from "Kaawa Creek, New Zealand, late Tertiary."

Compared to *Semeloidea*, the lower margin of the hinge plate of *Temblornia* is more arched, the posterior cardinal is less curved and the radial riblets, externally, are more numerous and finer.

Three species of this subgenus have been reported, the type species from strata of middle Miocene age in California, one of Miocene age in Ecuador (672) and one as yet undescribed species in the Gatun Formation of Miocene age in the Panama Canal Zone. To these we add a new species from the San Diego Pliocene.

Bornia (*Temblornia*) *frankiana* n. sp.

Text Figure 11

Description. — Shell, a right valve, small, elongately trigonal, moderately inflated, nearly equilateral, slightly longer posteriorly; anterior and posterior margins nearly straight, near the ends rounding into the ventral margin; 10 rounded radial ribs on the anterior end just posterior to the margin and 7 similar ones, somewhat flattened, on the posterior end, the ribs are faint dorsally but become gradually more strongly developed toward the ventral margin; ribs separated by interspaces which are a little wider than the ribs and in these, toward the ventral margin, lines of growth are accentuated (perhaps a result of erosion); remainder of the valve smooth except for somewhat irregular lines of growth; hinge with 2 well developed cardinal teeth; interior of anterior and posterior ends of valve crenulated and slightly denticulated corresponding to the exterior sculpture. Length 6.5 mm, height 4.1 mm.



Text Fig. 11. *Bornia* (*Temblornia*) *frankiana* Hertlein and Grant, new species. Holotype (Los Angeles County Museum), right valve from Loc. 305C (LAM), near the Mexican boundary, southwestern San Diego County; Pliocene. Length 6.5 mm. A. View of exterior. B. View of interior. (Drawn by Dorothy Ludlow.)

Type specimen. — Holotype, a right valve, Invertebrate Paleontology Collection, Los Angeles County Museum.

Type locality. — Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base

and Meridian (see U. S. G. S. topog. Map, San Ysidro quad., rev. 1953.) San Diego Formation, middle Pliocene.

Range. — Known only from the type locality.

Remarks. — *Bornia* (*Temblornia*) *frankiana*, new species, differs from the two other described species of *Temblornia* in its more elongately trigonal outline and in the nearly straight anterior and posterior margins.

This species is named for the late Frank Stephens, Curator Emeritus, San Diego Society of Natural History, who aided us on many occasions during field collecting in the San Diego area.

FAMILY MONTACUTIDAE CLARK (673)

Shell generally small, ovate to oblong, thin or heavy, depressed or convex, the anterior side the longer. Ligament mostly internal, subumbonal or lodged in an elongated, oblique resilifer in the hinge margin behind the beaks. Surface smooth or with concentric growth lines and sometimes radial undulations. Habit of most species appears to be commensal. (Olsson, Mollusks of the Tropical Eastern Pacific, Paleo. Res. Inst.: Ithaca, New York, p. 233, 1961.) Eocene to Recent.

Key to Genera of Montacutidae

- A. Right valve with 2 cardinal teeth . . . *Pristes*
- B. Right valve lacking cardinal teeth . . . *Mysella*

GENUS MYSELLA ANGAS

Mysella Angas, Proc. Zool. Soc. London for 1877, p. 176, issued August, 1877. Sole species: *Mysella anomala* Angas. — Cotton and Godfrey, The Molluscs of South Australia (issued by the South Australian Branch of the British Science Guild: Adelaide), p. 224, 1938. "Genotype — *M. anomala* Angas." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 233, 1961. "Type species by monotypy, *M. anomala* Angas. Australian waters."

Rocheortia Velain, Compt. Rend. Acad. Sci. (Paris), Vol. 83, p. 285, July 24, 1876. *Rocheortia australis*, a *nomen nudum*. — Velain, Arch. Zool. Exper. Gen. (Paris), Vol. 6, p. 132, no earlier than November 12, 1877. — J. Q. Burch, (ed.), Min. Conch. Club South. California, No. 110 p. 1, June, 1951. — see K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 88, footnote 36, 1958. — Keen, Treatise on Invertebrate Paleontology (Geol. Soc. Amer. and Univ. Kansas Press), Pt. N. Moll. 6, p. N531, 1969. Type: *R. australis* Velain, figs. 3a, 3b. Saint Paul Island, Recent.

Type species (by monotypy). — *Mysella anomala* Angas [Proc. Zool. Soc. London for 1877, p. 176, August, 1877. "Hab. Shark Island, Port Jackson, in black mud, in 12 fathoms." — Laceron, Rec. Australian Mus., Vol. 24, No. 2, p. 18, figs. 23, 23a, 23b, 1956. New South Wales, Australia. — Keen, 1969, figs. 9a, 9b.]

Range. — Middle Miocene to Recent. Widely distributed in present seas, from 11 to 320 meters (to 175 fathoms).

Description. — Shell triangularly ovate, anterior end longer, sculpture concentric; left valve with a large, diverging, flattened tooth posterior to the triangular

resilifer; the anterior margin of the resilifer is thickened and margined to simulate a transverse tooth; in front of this is a small socket; right valve with the hinge margin on each side of the umbo produced, which is overlapped by the hinge line of the opposite valve; the posterior tooth-like edge interlocks above the cardinal tooth of the left valve, and the anterior which is shorter, is received in the socket in front of the ridge-like edge of the resilifer. These tooth-like margins of the right valve represent cardinal rather than lateral teeth. (Cotton and Godfrey.)

Remarks. — Laceron (1956, p. 18) pointed out that a feature common to all species of *Mysella* "is that the horizontal lateral processes in the right valve are caused by a peculiar infolding of the dorsal margin on either side of the umbos, and are in no sense lateral teeth as generally understood."

Fossil and Recent species attributed to this genus have been recorded from various regions. The genus has been reported from Pliocene to Recent in western United States. About 12 species referred to "*Rocheortia*" or *Mysella* have been reported living in west American waters between the Aleutian Islands, Alaska, and the Gulf of California, and others have been described from more southern waters.

Some authors treat *Mysella* and *Rocheortia* (674) as separate genera. Others place *Rocheortia* either as a subgenus of *Mysella* or in the synonymy of that genus.

The species of small bivalves belonging to *Mysella* and related genera, will remain difficult to identify specifically until careful comparative studies are made and adequate illustrations are available.

Dell (675) discussed some of the Antarctic and subantarctic species of *Mysella*.

Mysella tumida Carpenter

Plate 44, Figures 2, 3, 4, 5, 7, 8, 12;

Plate 45, Figures 5, 8, 9, 12

Tellinya tumida Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 602, 611, 643, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 88, 97, 129, 1872.

Mysella tumida Carpenter, Dall, Proc. U. S. Nat. Mus., Vol. 21, No. 1177, pp. 881, 892, pl. 87, fig. 7 ("type specimen." "California."), 1899. "Alaska Peninsula and south to San Diego, California," Recent. — Abbott, Amer. Seashells (D. Van Nostrand Co.), p. 397, fig. 80b, 1954. "Alaska to Lower California." — K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 88, pl. 7, figs. 8-12, 1958. Earlier records cited.

Rocheortia tumida Carpenter, Dall, U. S. Nat. Mus., Bull. 112, p. 37, 1921. "Shumagin Islands, Alaska, to San Diego, California." — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 40, 1924. "Oreas and Turn Islands, Wash., along shore." Shumagin Islands, Alaska, to San Diego, California. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 132, pl. 54, figs. 11-14, 1924. Same range as in preceding reference.

Type specimen. — No. 5242, United States National Museum.

Type locality. — Indicated as from Puget Sound and the neighborhood; Vancouver Island, Straits of San Juan de Fuca, and adjoining shores of Washington territory;

also the region between San Diego and San Pedro, California. "The holotype bears the label 'Puget Sound, Kennerley'" (Palmer, 1958.)

Range. — Middle Pliocene to Recent. Recent from the Shumagin Islands, Alaska, to Scammon Lagoon, Lower California, Mexico, shore to 88 meters (48 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A, 318.

Original description. — "Between *bidentata* and *substriata*: ossicle minute." (Carpenter, 1864.)

Supplementary description. — T. t. subtriangulari, subovatâ, laevi, solidiore, tumidiore, valde inaequaliterali; cinereâ, epidermide pallide olivaceâ, concentrice striatâ indutâ; marginibus dorsalibus subrectis, ventrali excurvato; intus, dentibus cardinalibus valvâ sinistrâ validissimis, curtis, extantibus, postico longiore, valvâ dextrâ callositatibus marginalibus, dentibus nullis; cartilagine validiore, ossiculum parvum in medio gerente; cicatricibus adductoribus à cardine valde remotis. Long. .115, lat. .125, alt. .06. (Carpenter, Proc. Acad. Nat. Sci. Philadelphia, Vol. 17, p. 58, 1865.)

Remarks. — Many valves here referred to *Mysella tumida* are present in the collections from near the Mexican boundary. These are small, the largest about 3 mm long, rounded trigonal to trigonally ovate and gently convex. The left valve, as mentioned by Palmer, has two cardinal teeth which are quite large for the size of the shell.

This is the first record of the occurrence of this species in the San Diego Formation. Woodring (676) reported it from the Graciosa Member of the Careaga Sandstone in the Santa Maria district in beds of late Pliocene age.

The fossils from San Diego are quite similar to specimens from Puget Sound in the collections of the California Academy of Sciences which were identified by T. S. Oldroyd as "*Rocheortia*" *tumida*. Some of the specimens in the present collection are more elongate than others. Similar forms were illustrated by Addicott (U. S. G. S., Prof. Paper 523-C, p. C4, pl. 4, figs. 12, 13, 1966) under the name of "*Mysella* cf. *M. tumens*" from beds of Pleistocene age at Point Año Nuevo, San Mateo Co., California.

The species described by Dall as *Mysella pedrona* (677) is elongate in outline but the hinge was described as "feeble." The illustration of the type shows the hinge to be quite different from that of *M. tumida*. Another elongate species, was described but not illustrated, under the name of *Rocheortia golischi* Dall (678). MacGinitie (679) discussed the shell characters of *M. pedrona* and *M. golischi* and stated that the two are distinct species. She mentioned that on *M. pedrona* the umbones are nearer the anterior end and that the posterior end (more elongate than the anterior end) slopes more abruptly downward than that of *M. golischi*.

GENUS PRISTES CARPENTER

Pristes Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 611, 643, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 97, 129, 1872. Sole species *Pristes oblongus* Carpenter. — Vokes, Jour. Paleol., Vol. 30, No. 3, p. 768, May, 1956. — K. V. W.

Palmer, Geol. Soc. Amer., Mem. 76, p. 89, 1958. "Type species by monotypy *Pristes oblongus* Carpenter." Not *Pristis* Linek, 1790. Not *Pristis* Müller and Henle, 1837.

Pristiphora Carpenter, Proc. Calif. Acad. Nat. Sci., Vol. 3, p. 210, February, 1866.

Not *Pristiphora* Latreille, 1810. Hymenoptera.

Serridens Dall, Proc. U. S. Nat. Mus., Vol. 21, No. 1177, p. 880, June, 1899. A new name for *Pristiphora* Carpenter, 1866. Not *Pristiphora* Blanchard, 1835.

Type species (by monotypy). — *Pristes oblongus* Carpenter.

Range. — Middle Pliocene to Recent. Recent, intertidal, commensal with *Ischnochiton*.

Description. — Shell oval, with two diverging teeth in each valve, the anterior being conspicuously shorter than the posterior, sulcated near the beaks, ligament situated in a groove between them. (Tryon, G. W., Jr., Structural and Systematic Conchology, Vol. 3, p. 220, 1884.)

Remarks. — This genus of small leptonids is represented solely by the type species which lives only in eastern Pacific waters. Vokes (1956), and K. V. W. Palmer (1958), discussed the nomenclatorial problems concerning the genus name *Pristes*. This genus is reported here for the first time from beds of Pliocene age.

Pristes oblongus Carpenter

Plate 44, Figures 9, 10, 13, 14

Pristes oblongus Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 611, 643, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 97, 129, 1872. P. 611 (97). "S. Diego." P. 643 (129), "D" [=] "The region between S. Diego and S. Pedro." — K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 89, pl. 9, figs. 11-13, 1958. "San Pedro to San Diego, California [San Pedro] (type); Monterey, California to San Hipolito Point, Lower California (Burch)."

Pristiphora oblonga Carpenter, Proc. Calif. Acad. Sci., Vol. 3, p. 210, February, 1866. "Hab. San Diego; 1 worn valve among shell washings. Cooper."

Serridens oblonga Carpenter, Dall, Proc. U. S. Nat. Mus., Vol. 21, No. 1177, p. 880, 1889. "San Pedro, California" — T. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 135, pl. 54, figs. 5, 6, 7, 8, 1924. "Type locality, San Diego, California." "Range: Puget Sound to Coronado Islands, Lower California." — J. Q. Burch, Min. Conch. Club South. California, No. 40, p. 16, October, 1944. Monterey, California, to San Hipolito Point, Lower California. Commensal with *Ischnochiton conspicuus* Carpenter, and *I. magdalenensis* Hinds.

Type specimen. — Lectotype No. 15592, United States National Museum (Palmer, 1958).

Type locality. — "S. Diego" and "The region between San Diego and San Pedro," Carpenter, 1864. San Pedro, California, selected as type locality by Palmer (1958).

Range. — Middle Pliocene to Recent. Recent from Monterey, California, to San Hipolito Point, Lower California, commensal with *Ischnochiton conspicuus* Carpenter, *I. heathiana* Berry and *I. magdalenensis* Hinds.

Occurrence in San Diego Fm. — L.A.M. 305, 305A.

Original description. — "Like *Tellimya*, with long marginal teeth, serrated near hinge." (Carpenter, 1864.)

Supplementary description. — *P. t. oblonga*, parvâ, subquadrata, valde inaequilaterali; parte anticâ fere nulla, marginibus, dorsalibus subrectis, fere rectangulatis, ventrali parum excurvato, postico rotundato; umbonibus antie flectis; lunulâ parvâ, concavâ: intus, v. sinistr., dent. lat. post. per totam longitudinem dorsalem decurrente, parte cardinali acutâ, alte transversim sulcatâ, ant. secundum lenulam incurvato curto, serrato; cicatr. adduct. sub fines dentium sitis. Long. 0.14, lat. 0.10, alt. ?0.06. (Carpenter, 1866.)

Remarks. — Nine single valves of *Pristes oblongus* are present in the collections from near the Mexican boundary. This is the first record of its occurrence in the San Diego Formation. Previously it was reported as a fossil by Valentine (680) from beds of Pleistocene age at Crown Point, San Diego, California.

This small, elongate leptonicid was reported from Puget Sound by I. S. Oldroyd, 1924, but later authors have cited it as ranging northward only to Monterey, California. It lives commensal with chitons.

FAMILY SPORTELLIDAE DALL (681)

Shells are generally small, ovate to narrowly elongate, thin and usually white in color. The umbones are usually prominent, sometimes near the middle, or much closer to the anterior end. Hinge generally with one or two large teeth in each valve. Ligament largely external, occasionally showing a small, internal resilium. Surface smooth or roughened with growth threads, sometimes heavily pustulated. (Olsson, Mollusks of the Tropical Eastern Pacific, (Paleo. Res. Inst.: Ithaca, New York), p. 241, 1961.) Late Jurassic (682) (Sequanian); Paleocene to Recent.

GENUS BASTEROTIA MAYR IN HÖRNES

Harlea Gray, Synop. Brit. Mus., 1842, p. 78 [no species cited]. See E. A. Smith, Proc. Zool. Soc. London, April 1, 1890, p. 303.

Eucharis Reclúz, Jour. de Conchyl., Vol. 1, p. 164, 1850.

Type, *Corbula quadrata* Hinds.

Not *Eucharis* Latreille, 1804.

Basterotia Mayr in Hörnes, Verhandl. K. K. Zool.-Bot. Gesell. Wien, Bd. 9, Abh. p. 71, 1859. *Basterotia corbuloides* Hörnes cited and illustrated. — Woodring, Carnegie Inst. Washington, Publ. No. 366, p. 190, 1925. "Type (by monotypy). — *Basterotia corbuloides* Mayer." [The genus placed in the family *Basterotidae*.] — Hertlein and Strong, Zoologica, Vol. 31, Pt. 4, p. 137, 1947. "Type (by monotypy): *Basterotia corbuloides* Hörnes." — Olsson Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 242, 1961. "Type species by monotypy, *Basterotia corbuloides* Hörnes."

Not *Basterotia* Bayle in Jousseume, 1884. Gastropoda.

Type species (by virtual monotypy.) — *Basterotia corbuloides* Hörnes, 1859, p. 71, three figs., "Wiener Becken." Miocene. See also Hörnes, Abhandl. K. K. Geol. Reichsanst., Bd. 4, p. 40, pl. 3, figs. 11a-g, 1870. Various localities cited in Vienna Basin, Austria. Miocene.

Range. — Miocene to Recent. Recent in the eastern

Pacific from the Gulf of California to Ecuador and the Galápagos Islands. Also Caribbean and Indopacific; from 11 to 1170 meters (6 to 640 fathoms).

Description. — Shell small, subquadrate corbuliform, with a sharp angle or carination running from the beak posteriorly. Valves convex and usually solid, white, the beaks prosogyrate. Surface marked with fine concentric lines of growth and a sprinkling of fine or coarse granules. Ligament external, attached to a short, stout, plate-like nymph. Hinge with a large, hook-shaped cardinal tooth in each valve, bordered behind or in front by a deep socket; in the right valve, the socket lies in front of the tooth and in the left valve behind. There is no pallial sinus. (Olsson, 1961, p. 242.)

Remarks. — Four species referred to this genus have been reported from the late Cenozoic of the tropical eastern Pacific, one of which is Recent.

Lamy (683) listed 13 Recent species which he referred to *Basterotia*. Some of these were placed in other genera by later workers.

SUBGENUS BASTEROTELLA OLSSON AND HARBISON

Basterotella Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 97, November 6, 1953.

Type species (by original designation and by monotypy). — *Pleurodesma floridana* Dall [Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1630, pl. 57, fig. 30, October, 1903. "Pliocene marls of Shell Creek, Florida; long. 14.5 mm." See also Olsson and Harbison, 1953, p. 98, pl. 8, fig. 2; pl. 9, figs. 1, 1a (as *Basterotia* (*Basterotella*) *floridana*.) Florida, Pliocene].

Range. — Miocene to Recent. Recent in the eastern Pacific from the Gulf of California to Ecuador and the Galápagos Islands.

Description. — Like *Basterotia* in form, angled or carinate umbo, surface granulation and large, hook-shaped, subumbonal cardinal tooth, but differs in having both an internal and external ligament. Nymphal plate small and narrow, the resilial pit a small scar on its inner and lower face. (Olsson and Harbison, 1953.)

Remarks. — The shell of the type species of *Basterotella* bears scattered granules which are strongest near the anterior-ventral side. These granules are said to be present on the right valve of Caribbean members of this group, but may be lacking on the left valve. No such granules have been described as occurring on the valves of west American species assigned to this subgenus.

Four species described from the tropical and subtropical eastern Pacific have been assigned to *Basterotella*. Three species described from the Gulf of California region, have been reported as follows: one from strata of late Pliocene age, two from the Pleistocene and one of these Recent. An additional species living in Ecuador and the Galápagos Islands was described by Olsson.

This is the first record of *Basterotia*, subgenus *Basterotella*, from California.

Basterotia (*Basterotella*) *hertleini* Durham Plate 57, Figures 6, 11

Basterotia hertleini Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 94, pl. 25, figs. 4, 11, August 10, 1950.

Basterotia (*Basterotella*) *hertleini* Durham, Emerson and Hertlein, Trans. San Diego Soc. Nat. Hist., Vol. 13, No. 17, p. 355, figs. 4g-j, 1964. Marquer Formation, Puerto Balandra, Carmen Island, Gulf of California, Pliocene.

Type specimen. — Holotype No. 32274, University of California (Berkeley), Department of Paleontology, Type Collection.

Type Locality. — Loc. A 3670 (U. C.), "Upper Pliocene, Puerto Balandra, Carmen Island. From sands at left end of outcrop and below base of coral reef (loc. A3534)."

Range. — Middle and late Pliocene.

Occurrence in San Diego Fm. — L.A.M. 305C.

Original description. — Shell in general resembling *B. peninsulare* (Jordan) but more elongate and normally less inflated; subquadrate, moderately thin, ornamented by irregular concentric growth lines only; beaks not very prominent; an angulation running from umbo to posterior ventral margin; umbos situated about a fourth the length from the anterior end; a prominent projecting cardinal tooth in each valve, with adjacent deep "socket" anterior to it in right valve. Length 13.2 mm, height 7.8 mm, thickness 3.6 mm (one valve). (Durham.)

"This species may be distinguished from *B. peninsulare* (Jordan) by its greater length, greater width between the angulation and the posterior ventral margin, normally lesser inflation, and usually less sharp angulation." (Durham.)

Remarks. — One right valve of this species, 11 mm long and 7.3 mm high, is present in the collection from Loc. 305C (LAM) from near the Mexican boundary. It is similar to specimens of *Basterotia hertleini* from the type locality on Carmen Island in the Gulf of California.

The shell of *B. hertleini* is very similar to that of *B. ecuadoriana* Olsson (684), a Recent species described from Ecuador. In comparison to the Recent species the shell of *B. hertleini* is longer in proportion to the height, more convex, with a less expanded posterior dorsal area and a narrower anterior end.

The valve of *B. hertleini* from the San Diego Formation differs from *B. peninsularis* Jordan (685) in the particulars mentioned by Durham.

Olsson mentioned that the Recent species cited by Hertlein and Strong (686) under the name of *Basterotia peninsularis* from West Mexico, Nicaragua, and the Galápagos Islands, is probably referable to *B. ecuadoriana*. We have examined those specimens, and also some others (787) from the Gulf of California upon which records of *B. peninsularis* Jordan were based. The beaks of these are less elevated and more anteriorly placed than those on the species described by Jordan. This bears out Olsson's suggestion that *B. ecuadoriana* lives in the Gulf of California. The range of this species is from San Luis Gonzaga Bay, east coast of Lower California (and probably from the head of the Gulf), to Manta, Ecuador, and the Galápagos Islands.

The only other species of *Basterotia* described from the eastern Pacific is *B. californica* Durham (688) from strata of Pleistocene age in Lower California. Compared to the three other species, it is much longer in proportion to the height. Keen (1971, p. 145) placed both *B. californica* Durham and *B. ecuadoriana* Olsson in the synonymy of *B. hertleini*.

SUPERFAMILY LUCINACEA FLEMING (689)

Allen (690) discussed the form and adaptation to habitat of this superfamily, and Boss (*Nautilus*, vol. 82, No. 4, pp. 128-130, 1969) recently discussed the relationships of this group of mollusks.

FAMILY LUCINIDAE FLEMING (691)

Shells small or large, subcircular to suborbicular, generally equivalve, but occasionally somewhat inequivalve (*Miltha*), thin or heavy, in the latter case, the interior may be coarsely pustulose. Hinge when typical has two strong cardinal teeth and an anterior and posterior lateral tooth or its socket in each valve, the posterior lateral element placed distantly at the end of the ligamental scar; in other forms, the hinge may be degenerate to a greater or lesser degree, the cardinal teeth and sometimes the laterals become obsolete and often wholly lacking in the adult. The ligament is external, attached to a deeply immersed scar lying below the margin of the valve. Adductor scars of unequal size, the anterior scar typically much larger, divided, the lower segment narrow and elongated and free from the pallial line. The pallial line itself entire and placed near the margin. Ventral margin smooth or crenulated. Surface sculpture, formed by radial or concentric elements or a combination of both. Often with a scaly periostracum. (Olsson, *Mollusks of the Tropical Eastern Pacific* (Paleo. Res. Inst.: Ithaca, New York), p. 206, 1961). Silurian to Recent.

Remarks. — Dall stated that the shell material of the members of this family is usually porcelainous or chalky and the periostracum may be hardly discernible or may be scaly in character.

The largest member of the family Lucinidae, as mentioned by Cox (692), is the species described as *Lucina megameris* Dall from the late Eocene of Jamaica. A specimen studied by Cox is 280 mm long and 290 mm high, the inflation of the valves about 85 mm.

Chaven (693) discussed the classification of this family in several papers.

GENUS *LUCINA* BRUGUIÈRE

Lucina Bruguière, *Encycl. Méth.*, *Tabl. Vers*, pls. 284, 285, 286, 1797. [Name and figures only. The illustrations identified later include *Lucina pensylvanica* Linnaeus, *L. jamaicensis* Lamarek and *L. edentula* Linnaeus.] — Stewart, *Acad. Nat. Sci. Philadelphia*, *Spec. Publ.* No. 3, p. 175, 1931. Type as designated by Schumacher.

Type species (designated by Schumacher, *Essai Nouv. Syst. Habit. Vers Test.*, p. 165, 1817). — *Venus pensylvanica* as illustrated by Chemnitz, *Syst. Conchyl.* — *Cab.*, Bd. 7, p. 12, pl. 37, fig. 394, 1784. "an den Stranden der westindischen Meere" and "von den Ufern der Dänischen westindischen Eylande." [*Venus pensylvanica* Linnaeus, *Syst. Nat.*, ed. 10, p. 688, 1758. "Habitat in America septentrionali." Ref. to Argenville, *Conch.*, pl. 24, fig. N. Also illustrated by Reeve, *Conch. Icon.*, Vol. 6, *Lucina*, species 29, pl. 6, fig. 29, 1850. — Lamy, *Jour. de Conchyl.*, Vol. 65, No. 2, p. 172, 1920. (Fig. of hinge.) — M. Smith, *East Coast Mar. Shells* (Edwards Bros.: Inc.), p. 46, pl. 15, figs. 1a, 1b, 1945.]

Range. — Jurassic to Recent. Recent in from 15 to 7,224 meters (8 to 3950 fathoms).

Description. — Shell orbicular in outline, moderately inflated, occasionally subglobose, valves closed, lunule usually well developed, no escutcheon, an oblique depressed area present along the posterior dorsal margin; sculpture of concentric lamellae or lines of growth, sometimes also with radial elements; hinge with cardinal teeth and sometimes with laterals or these may be obsolete; ligament semi-internal; anterior muscle impression elongated within pallial line, posterior impression oblong; pallial line entire.

Remarks. — Many of the west American species of *Lucina* have appeared, at times, in the literature associated with the generic name *Phacoides*. The name *Phacoides* was first used by Blainville in a vernacular sense in 1824 (see Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. 3, p. 180, 1930). Apparently, the first usage of it as a valid generic name was by Gray (Proc. Zool. Soc. London for 1847, p. 195) who placed it in the synonymy of *Lucina* with the type species "*Ven. jamaicensis*." Some authors retain *Phacoides* as a subgenus of *Lucina* (Olsson, 1961, p. 208), others recommend its abandonment (see Chavan, 1937, p. 141; Keen, 1958, p. 93).

Lucina is widely distributed both geographically and geologically. It is well represented in the Cenozoic of western North America. Six species occur in the San Diego Formation.

At the present time there are numerous species living in the seas. Lamy (694) published a catalogue of the Recent species in the collections of the Museum National d'Histoire Naturelle in Paris and the tropical west American species have been discussed by several authors (695).

SUBGENUS *HERE* GABB

Here Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 28, February, 1866. *Lucina (Here) richthofeni* Gabb included in original list of species. — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 180, 1930. Type as indicated by Stoliczka. — Chavan, Jour. de

Conehyl., Vol. 81, No. 3, p. 202, 1937. Genotype, *Here richthofeni* Gabb.

Type species (designated by Stoliczka, Geol. Surv. India, Palaeo. Indica, Ser. 6, Cret. Fauna South. India, Vol. 3, pp. XIX, 251, 1871). — *Lucina (Here) richthofeni* Gabb [Geol. Surv. Calif., Palaeo., Vol. 2, p. 29, pl. 8, figs. 49, 49a, 49b, 1866. "Locality: San Fernando Valley, north of Los Angeles; Pliocene." — Stewart, 1930, p. 181, pl. 15, fig. 3; pl. 17, fig. 5, 1930. See also Chavan, 1937, p. 203, fig. 3].

Range. — Eocene to Recent. Recent from the intertidal zone to 132 meters (72 fathoms).

Original description. — Shell having all of the usual characters of *Lucina*, except that the lunule is very deeply excavated, penetrating the hinge-plate, and almost perforating it; bounded anteriorly by the anterior lateral tooth, and posteriorly by the cardinal teeth. (Gabb, 1866.)

Remarks. — This subgenus appears in the Eocene of Europe, South America, Florida, western North America, and probably in other regions. It is represented from Eocene (697) to Recent in the Cenozoic of western North America. One species occurs in the San Diego Formation.

The species of this group are characterized by their rounded subglobular form, very deep lunule, and well developed concentric sculpture.

Chavan (698) pointed out that *Here* differs from *Linga* de Gregorio (699) in possessing a very deep lunule which results in the dwarfing of the left anterior cardinal tooth and complete lack of a right anterior cardinal, and in possessing more elongated posterior lamellae. The two groups are quite similar, but for the present at least we have followed traditional classification in leaving *Here* as a subgenus of *Lucina*.

Illesca Olsson (700) described as a subgenus of *Here* differs in that the lunule is "entirely immersed into the hinge-plate and in both valves seems to have completely effaced the anterior cardinal."

In west American waters, *Here* is represented at the present time by a single species which ranges from San Pedro, California, to Mazatlan, Mexico.

Key to Genera and Subgenera of *Lucina*

- | | |
|--|---|
| A. Hinge with cardinal teeth but lacking laterals | c. Lunule nearly equally divided between the two valves . . . <i>Lucina</i> s. s. (696) |
| a. Valves equally convex; strong concentric lamellae <i>Lucinoma</i> | cc. Lunule in greater part or almost entirely in the right valve. <i>Epilucina</i> |
| aa. Valves unequally convex; concentric sculpture of growth lines only <i>Miltha</i> | |
| B. Hinge with both cardinal and lateral teeth | aa. Surface with radial and concentric sculpture |
| a. Surface with concentric sculpture only | d. Radial and concentric sculpture strong, spiny; margin denticulate <i>Lucinisca</i> |
| b. Shell globose; lunule very deeply impressed. <i>Here</i> | dd. Radial and concentric sculpture feeble, unequal, margin smooth <i>Parvilucina</i> |
| bb. Shell moderately inflated; lunule not deeply impressed | |

Lucina (Here) excavata Carpenter

Plate 46, Figures 1, 2, 3

Lucina excavata Carpenter, Cat. Mazatlan Shells Brit. Mus., p. 98, November 1855. Mazatlan, Mexico. — Brann, Illustrations to "Catalogue of the Collection of Mazatlan Shells" by Philip P. Carpenter (Paleo. Res. Inst.: Ithaca, New York), pp. 13, 37, pl. 12, fig. 140, 1966. — Keen, Veliger, Vol. 10, No. 4, p. 396, pl. 56, fig. 23, 1968.

Lucina (Here) richthofeni Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 29, pl. 8, figs. 49, 49a, 49b, February, 1866. "Locality: San Fernando Valley, north of Los Angeles; Pliocene. Collected by Baron Richthofen."

Phacoides (Here) richthofeni Gabb, Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, pp. 810, 827, pl. 40, figs. 7, 9, 1901. "Catalina Island to Gulf of California, in 15 to 66 fathoms."

Phacoides richthofeni Gabb, Keep, West Coast Shells (The Whitaker & Ray Wiggin Co.: San Francisco), p. 69, fig. 45, 1911. "Catalina Island, Long Beach, and southward." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 174, 182, 1912. "San Diego - Purisima."

Lucina (Here) excavata Carpenter, Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 181, pl. 15, fig. 3; pl. 17, fig. 5, 1930. Earlier records cited, Miocene to Recent. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 290, pl. 14, figs. 2, 5, 10, 1931. Also cited from Oligocene to Recent. — Hertlein and Strong, Zoologica, Vol. 31, Pt. 3, p. 113, 1946. Gulf of California, Recent. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press), p. 94, fig. 188, 1958. Catalina Island, California, to Mazatlan, Mexico, in 16 to 66 fathoms. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 208, pl. 29, figs. 7, 7a, 1961.

Type specimen. — British Museum (Natural History) (Keen, 1968).

Type locality. — "Mazatlan." [Mexico.]

Range. — Late Oligocene (Wagner and Schilling) (701) to Recent. Recent from San Pedro, California, to Mazatlan, Mexico, in 27 to 121 meters (15 to 66 fathoms).

Occurrence in San Diego Fm. — L.A.M. 107, 305, 305A, 319. S.D. 70.

Original description. — L. t. albâ, tenui, complanată; suborbiculari; striis concentricis exillimis; postice angulatâ, umbonibus incurvatis; lunulâ parvâ, alte excavatâ, dent. card. et. lat. haud magnis; impressionibus muscularibus posticâ ovali, anticâ valde elongatâ; margine integro. (Carpenter.)

Distinguished by the very small, most deeply cut lunule, bounded on one side by the cardinal, on the other by the anterior lateral tooth. A larger lunular portion is marked out by a line, and the posterior margin is slightly bi-angulated. Smallest valve 0.03 across. Largest, long. 0.38, lat. 0.41, alt. .12. (Carpenter.)

Remarks. — About 75 valves of this species from the San Diego Formation, varying in size from 6.4 to 19.3 mm in length, have been available for study. Most of these are in the collections of the Los Angeles County Museum from near the Mexican boundary but a few are from San Diego. A right valve, 12.4 mm long, in the collections of the San Diego Society of Natural History, was collected by Samuel

Harter in Balboa Park.

The globosity of the various valves varies as does the spacing of the ribbing which may be closely or widely separated.

Through the courtesy of Dr. Horace G. Richards, Academy of Natural Sciences of Philadelphia, we have been able to examine casts of Gabb's type of *Lucina richthofeni*. We have not observed any essential differences between these and Recent specimens of *L. excavata* from the Gulf of California. We have, albeit regretfully, placed Gabb's species from the Pliocene in the synonymy of the Recent form.

Lamy (702) first stated that *Lucina excavata* represented the young form of *L. richthofeni* Gabb and later, Stewart, who studied Gabb's type specimens, placed *L. richthofeni* in the synonymy of Carpenter's species. Both Lamy and Stewart, pointed out that *Lucina "excavata?"* cited by d'Orbigny (703) in 1850 was based upon *Cytherca excavata* Morton (704) from the Cretaceous of New Jersey, which species is the type of *Cyprimeria* Conrad. It is not referable to the genus *Lucina* and does not affect the nomenclature of *L. excavata* Carpenter.

A subspecies, *Lucina (Here) excavata temblorensis* Adegoke (705), of middle Miocene age, was described from the Coalinga district. It is said to differ from the typical subspecies in the more prominent beaks, less circular outline and in other features.

SUBGENUS *LUCINISCA* DALL

Lucinisca Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, p. 805, August 22, 1901. "Type, *Lucina nassula* Conrad." — Chavan, Jour. de Conchyl., Vol. 81, No. 4, p. 238, 1937. Genotype: *L. nassula* Conrad.

Type species (by original designation). — *Lucina nassula* Conrad [Proc. Acad. Nat. Sci. Philadelphia, Vol. 3, p. 24, 1846. "Tampa Bay, Florida." Recent. Illustrated by Conrad, Amer. Jour. Conch., Vol. 2, Pt. 3, p. 281, pl. 15, fig. 7, 1866 (as *Lucina lineata*). "Inhabits Tampa Bay, Florida." — Perry and Schwengel, Marine Shells of the western coast of Florida (Paleo. Res. Inst.: Ithaca, New York), p. 64, pl. 11, fig. 65, 1955.]

Range. — Early Miocene to Recent. Recent in warm temperate and tropical marine waters, from the intertidal zone to 183 meters (100 fathoms).

Original description. — Shell lentiform, white, with well-marked dorsal areas, the sculpture reticulate and muricate, the right anterior cardinal obsolete. (Dall.)

Remarks. — The shells of the subgenus *Lucinisca* are characterized by their scaly reticulate sculpture, only slightly asymmetric lunule and by their denticulate inner margins. Chavan (706) published illustrations of the hinge of *Lucina cribraria* Say, a member of this subgenus.

The members of this subgenus are almost entirely confined to the eastern and western coasts of the Americas where they are known to occur from early Miocene to Recent. Three species referred to *Lucinisca* have been reported from strata of Miocene age in Japan.

Three species and one subspecies of *Lucinisca* occur in west American marine waters between Santa Barbara, California (Lat. 34°23'N.), and Tumbez, Peru. During late Pleistocene time one of these ranged north to Tomales

Bay, California (Lat. 38°18 N.).

Key to Species and Subspecies of *Lucinisc*

- A. Concentric ribs closely spaced *nuttalli*
- B. Concentric ribs widely spaced (subspecies) *antecedens*

Lucina (Lucinisc) nuttalli Conrad
Plate 45, Figures 1-4; Plate 46, Figure 21

L[ucina]. nuttalli Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 255, pl. 20, fig. 2, 1837. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 62, "Pacific Beach," p. 133, "Pliocene. — San Diego (Arnold)," 1903. — Arnold, U. S. G. S., Prof. Paper 47, p. 28, 1906. "Pacific Beach, north of San Diego, San Diego County." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) cited.

Lucina nuttalli Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "well at San Diego," "Pliocene." — Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 27, 28, 1878. P. 11, Later Tertiary of San Diego; p. 27, lower bed (A), San Diego Peninsula; p. 28, San Diego well. — Orcutt, West. Amer. Sci., Vol. 6, Whole No. 45, p. 70, Pacific Beach, Tertiary; Whole No. 46, p. 85, Dall's record (1874) cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited.

Phacoides nuttalli Conrad, Gardner, Jour. Entom. Zool., Vol. 9, No. 3, p. 107, pl. 1, fig. 16, 1917. Laguna Beach, California, Recent. — Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 126, 1924. "Pliocene at San Diego." Also other localities. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 84, 1929 (as *Phacoides nuttalli*). "San Diego Pliocene." — Johnson and Snook, Seashore Animals of the Pacific Coast (Macmillan Co.: New York), ed. 1935, p. 438, fig. 414.

Lucina (Myrtea) nuttalli Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 288, pl. 14, figs. 4a, and 4b (Recent), fig. 18 (Pliocene east of Fernando Pass, Los Angeles Co., 1931. "Pliocene of Pacific Beach, San Diego (Arnold, 1903)."

Lucina (Lucinisc) nuttalli Conrad, Hertlein and Strong, Zoologica, Vol. 31, Pt. 3, p. 114, 1946. Santa Barbara California, to Manzanillo and the Tres Marias Islands, Mexico. Also late Miocene to Recent. — Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 76, pl. 18, figs. 4, 5, 1950. Upper Pliocene to Recent. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 96, fig. 191, 1958. Southern California to the Tres Marias Islands, Mexico.

Lucinisc nuttalli Conrad, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 40, pl. 18, fig. d, 1968. Balboa Park, San Diego, Pliocene.

Type specimen. — Two syntypes, 61.5.20.87, British Museum (Natural History) (A. M. Keen, Veliger,

Vol. 8, No. 3, p. 169, 1966).

Type locality: "Inhabits California with the above" [that is, *Lucina californica* and *L. bella* which "Inhabits muddy marshes near Sta. Diego; common."]

Range. — "cf." Early Miocene (Vaqueros; Temblor). Late Miocene to Recent. Recent from Santa Barbara, California, to Punta Peñasco and San Felipe in the Gulf of California and south to Manzanillo, and the Tres Marias Islands, Mexico; littoral zone to 46 meters (25 fathoms).

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 957, 1129, 1178, 1400, 1401, 1402, 1415, 28880, 28885, 28886, 28892. L.A.M. 104, 107, 302, 305, 305A, 318, 319, 323. S.D. 21, 29, 38, 79, 80, 331, 365, 408. U.C.L.A. 294, 302, 312, 331, 1386, 2359.

Original description. — Shell lenticular, slightly compressed; disks cancellated; concentric lines very regular, lamelliform, prominent; anterior fold small, marginal; extremity emarginate above; cardinal and lateral teeth distinct; inner margin minutely crenulated. (Conrad.)

Remarks. — Over 100 valves of this species from the San Diego Formation have been available for study. Most of these are in the collections of the Los Angeles County Museum from near the Mexican boundary and others from San Diego. One of the largest valves from Loc. 305 (LAM), is 25.9 mm. long, 25 mm high and the convexity 7.7 mm.

This species occurs fairly commonly in the San Diego Formation. The scaly, reticulate sculpture and denticulate inner margins are features which serve to separate this species and its subspecies from others of *Lucina* which occur in strata of Pliocene age in San Diego.

Variation in the degree of rounding of the outline and in the convexity was observed in a series of specimens of *L. nuttalli*. Durham (707) mentioned specimens from beds of late Pliocene age in the Gulf of California region which were more tumid than usual for this species, but he acknowledged that occasional Recent specimens are nearly as convex.

Specimens cited as "*Phacoides (Lucinisc) cf. nuttalli*" (708) have been recorded from beds of early Miocene age in southern California and the species is well known in Pliocene and Pleistocene beds in southern California and in Lower California.

A subspecies, *Lucina nuttalli antecedens* Arnold, was described from strata of Pliocene age in Santa Barbara Co., California. *Lucina nuttalli centrifuga* Dall (709), described as a variety from the Gulf of California, has the concentric lamellae near the beaks widely spaced, more elevated and fringed with flat spinules. Some specimens identified as this subspecies from the Gulf of California which we have observed are very similar to young specimens of the species later described as *Lucina liana* Pilsbry (710).

Fossils from Miocene strata in Japan have been recorded in the literature by Nomura (711) under the name of *Lucina nuttalli* and another species *Lucina yokoyamai* Otuka (712), also from Miocene beds, is said to bear some resemblance to Conrad's species. We have not seen specimens but evidently *L. nuttalli* or a very similar form was present in Japan during Miocene time.

At the present time, *Lucina nuttalli* has been recorded

as ranging north to Santa Barbara, California, but during late Pleistocene it ranged north to Tomales Bay, California. We have examined specimens from the Tres Marias Islands, Mexico, which are typical *L. nuttalli*.

Lucina (Luciniscia) nuttalli antecedens Arnold
Plate 46, Figures 8, 9, 13, 14

Phacoides nuttalli Conrad, var. *antecedens* Arnold, Smithsonian Misc. Coll. (Quarterly Issue), Vol. 50, Pt. 4, p. 436 (separate p. 18), pl. 55, fig. 6, December 13, 1907. *Luciniscia nuttallii antecedens* Arnold, Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 207, pl. 86, pl. 20, fig. 3; pl. 21, fig. 6, 1950. Diatomaceous strata of Sisquoc Formation; Foxen Mudstone; Careaga Sandstone, late Pliocene.

Type specimen. — No. 165290, United States National Museum.

Type locality. — "Alcatraz asphalt mine, near Sisquoc, Santa Barbara County, California; locality No. 4471." "Fernando formation, lower Pliocene portion."

Range. — Middle and late Pliocene.

Occurrence in San Diego Fm. — L.A.M. 107, 124, 305.

Original description. — Shell averaging about 25 millimeters in longitude, very broadly elliptical in outline, longer than high, ventricose, and equivalve; beaks only moderately prominent, placed slightly anterior to middle of shell; base arcuate; anterior margin sloping more rapidly from beaks than posterior, the latter being nearly straight for about 6 or 8 millimeters from the beaks; both extremities quite regularly rounded, the posterior being possibly slightly more attenuate, sculpture consisting of numerous close-set subequal rounded radiating ridges and concentric ribs which are narrower than the radials, and spaced about twice the distance between two of the latter; the concentric ribs tend to become obsolete toward the periphery in adult specimens; the general appearance of the surface is decidedly cancellate. Lunule deep, small, and inconspicuous. Interior and hinge as in *P. nuttallii*. (Arnold.)

Dimensions. — Longitude, 23 mm; altitude 19 mm; diameter, 12 mm. (Arnold.)

Remarks. — A few valves in the collection from Loc. 305 (LAM), are here referred to *Lucina nuttalli antecedens*. The largest one is 18 mm long, 17.3 mm high and 4.5 mm in convexity. These specimens are rather rounded and the concentric lamellae on the major portion of the shell below the umbonal area, are widely spaced. These fossils are similar to others from the type locality of *L. n. antecedens*.

Arnold mentioned the diagnostic characters of this form as follows: "This variety is more ventricose, less angulated posteriorly, and its concentric ribs much wider spaced than the typical *nuttallii*." Woodring (1950) mentioned that the lamellae in the early stages on this subspecies are closely spaced but are succeeded by more widely spaced lamellae, which in later stages may be irregularly spaced.

The specimens here illustrated were selected from among an assemblage of a large number of individuals of *L. nuttalli* and it appears to us that the present subspecies is of doubtful value as a taxonomic unit. However, the presence of these specimens in the San Diego Formation, which reveal a tendency to develop the characters

mentioned by Arnold has led us to identify them with *L. n. antecedens*.

A cast, highly convex, from Reynard Way in San Diego and perhaps a few valves from Loc. 124 (LAM) are doubtfully referred to the form named by Arnold.

Woodring, 1950, recognized only *L. n. antecedens* in Pliocene strata at its type locality and in adjacent areas in Santa Barbara Co.

SUBGENUS *LUCINOMA* DALL

Lucinoma Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, p. 806, August 22, 1901. "Type, *Lucina filosa* Stimpson." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1362, October, 1903. Type, *Lucina filosa* Stimpson. — Chavan, Jour. de Conchyl., Vol. 82, No. 1, p. 80, 1938. Genotype, *Lucina filosa* Stimpson.

Type species (by original designation). — *Lucina filosa* Stimpson. [*Lucina filosa* Stimpson, Shells of New England, p. 17, 1851. Illustrated by Stearns, Proc. U. S. Nat. Mus., Vol. 13, No. 813, p. 220 (in text), pl. 17, figs. 5, 6, 1890. — Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, pp. 809, 824, pl. 40, fig. 11, 1901 (as *Phacoides (Lucinoma) filosa*). See also illustrations of hinge of *L. borealis* Linnaeus by Lamy, Jour. de Conchyl., Vol. 65, No. 2, p. 171, 1920.]

Range. — Late Oligocene to Recent, widespread. Recent species in western North America live in marine waters between Afognak Island, Alaska, and the Gulf of California, at depths of 15 to 1838 meters (8 to 1005 fathoms).

Original description. — Shell usually large, lentiform, white, with a conspicuous periostracum, concentrically lamellose or striated; the cardinal teeth developed, the inner pair usually bifid; the laterals obsolete or absent, the inner margins entire. (Dall.)

Remarks. — This group of lucinids with well developed concentric lamellar sculpture and weak lateral teeth is widely distributed geographically and geologically. Five and perhaps six species referable to *Lucinoma* have been described from late Oligocene to Recent, in western North America, and one of these, a Recent species, occurs in the San Diego Formation. Three Recent species live in west American waters.

Lucinoma also is represented in the late Cenozoic of eastern North America, South America, Europe, Japan, and New Zealand. It is well represented in the north Pacific. Hirayama (713) discussed several species of Miocene age occurring in Japan. Far to the southwest, Powell described *Myrtea (Lucinoma) taylori* (714) from beds of Awamoan, early Miocene age, in New Zealand. Dell (715) described a Recent species, *Lucinoma marwicki*, from a depth of 361 meters in the same region, and more recently Lemche added *Lucinoma galatheae* (716) to the known molluscan fauna of New Zealand.

In general, as pointed out by Dall, the members of *Lucinoma* prefer cool water. However, species also are known to occur in tropical waters. *Lucina (Lucinoma) chiripanica* Olsson (717) was described from beds of Pliocene age in Panama. Melville and Standen (718) recorded a tropical variety of *Lucina borealis* in the Persian Gulf and Thiele and Jaekel (719) cited the same species from the East Indies, and there are other examples.

Alucinoma Habe (720) differs from *Lucinoma* in lacking cardinal teeth.

Lucina (Lucinoma) annulata Reeve
Plate 46, Figures 12, 19

Lucina annulata Reeve, Conch. Icon., Vol. 6, *Lucina*, sp. 17, pl. 4, fig. 17, May, 1850.

Lucina borealis Linnaeus, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "Well at San Diego," "Pliocene." — Cooper, Calif. State Min. Bur. Seventh Ann. Rept. State Mineral., p. 246, 1888. "San Diego Well." — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, 1889. Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) cited and referred to *Lucina (Lucinoma) annulata*.

Not *Lucina borealis* Linnaeus, 1767. "In Oceano Europaeo."

Lucina acutilineata Conrad, Dall, Proc. U. S. Nat. Mus., Vol. 1, pp. 11, 28, 1878. P. 11, Later Tertiary of San Diego; p. 28, San Diego well. — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 86, 1889. Dall's record (1878) cited. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 132, 1903. "San Diego well (Cooper)." — Orcutt, quoted by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1878) cited.

Not *Lucina acutilineata* Conrad, 1848.

Phacoides acutilineatus Conrad, Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 179, 1909. "San Diego well (Cooper)."

Phacoides annulatus Reeve, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 174, 182, 1912. "San Diego-Purissima," Pliocene. — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 263, pl. 19, figs. 5a, 5b, 1918. "Range. — Alaska to Coronado Island, California (Dall)."

Phacoides (Lucinoma) annulatus Reeve, I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 38, pl. 37, figs. 5a, 5b, 1924. "Port Althorp, Alaska, to Coronado Islands, Lower California." Recent. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 126, pl. 33, figs. 5a, 5b, 1924. Same range as in preceding reference. Also, late Miocene, Pliocene, Pleistocene. — Abbott, American Seashells (D. Van Nostrand Co., Inc.: New York), p. 389, fig. 28f (p. 83), 1954. Alaska to southern California, in 8 to 75 fathoms.

Lucina (Myrtea) acutilineata Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 287, pl. 14, figs. 22a, 22b (Pleistocene of San Pedro), 1931. "San Diego well, middle Pliocene, San Diego (Cooper)."

Not *Lucina acutilineata* Conrad, 1849.

Lucinoma annulata Reeve, Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 97, fig. 197, 1958. Gulf of California. — Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 40, pl. 18, figs. a, b, c, 1968. Balboa Park, San Diego, Pliocene.

Type specimen. — Syntypes Nos. 1963 121/1-2, British Museum (Natural History).

Type locality. — "Hab. California?"

Range. — Late Miocene to Recent. Recent from Afognak Island (Kodiak group), and Macleod Bay,

Montague Island, Alaska, to Santa Inez Bay, Lower California; in 18 to 757 meters (10 to 414 fathoms) (Woodring, U. S. G. S., Prof. Paper 190, p. 53, 1938). Japan.

SUBGENUS *EPILUCINA* DALL

Epilucina Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, p. 806, August 22, 1901. "Type, *Lucina californica* Conrad." — Chavan, Jour. de Conchyl., Vol. 81, No. 4, pp. 249, 272, 1937. Genotype, *Lucina californica* Conrad.

Type species (by original designation). — *Lucina californica* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 255, pl. 20, fig. 1, 1837. Near San Diego, California. Hinge illustrated by Chavan, 1937, p. 274, fig. 10.

Range. — Bathonian, late Jurassic, to Recent (Chavan). Recent from the intertidal zone to 143 meters (78 fathoms).

Original description. — Shell veneriform, convex, all the hinge teeth developed, inner margins entire; otherwise like *Callucina*. (Dall.)

Remarks. — The shell of *Epilucina*, as pointed out by Chavan, differs in several important details from that of *Callucina* Dall (729) which has as its type *Lucina radians* Conrad. Among those differences are, the position of the lunule which is situated entirely in the right valve instead of partly in the left one, smooth inner margins and strongly projecting laterals (which on *Callucina* are very slightly developed).

We have not studied species upon which Chavan based the early range of this subgenus. *Clabornites* Stewart, 1930, was relegated to the synonymy of *Epilucina* by Chavan.

Lucina (Epilucina) californica Conrad
Plate 46, Figures 11, 16

L[ucina]. californica Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 255, pl. 20, fig. 1, 1837.

Phacoides californicus Conrad, Keep, West Coast Shells (The Whitaker & Ray-Wiggin Co.: San Francisco, Calif.), p. 67, fig. 43, 1911. "coast of central California". Also ed. by Baily, 1935, p. 82, fig. 55. — Johnson and Snook, Seashore Animals Pacific Coast (Macmillan Co.: New York), p. 438, fig. 415, 1935.

Lucina (Myrtea) californica Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 285, pl. 14, figs. 15a, 15b, 21a, 1931. Pliocene to Recent.

Codakia californica Conrad, Abbott, American Seashells (D. Van Nostrand Co., Inc.: New York, London; Toronto), p. 390, pl. 31, fig. c, 1954. "Crescent City, California, to Lower California."

Type specimen. — Location unknown to the present authors.

Type locality. — "Inhabits the coast of California with the above, but rare." [Preceding species is *Lucina bella* from "Inhabits muddy marshes near Sta. Diego; common."]

Range. —?Late Miocene; middle Pliocene to Recent. Recent from Crescent City, California, to San Ignacio Lagoon, Lower California, from the intertidal zone to 143 meters (0 to 78 fathoms). Reported from Alakai Point, Seattle, Washington, by Eyerdam (730).

Occurrence in San Diego Fm. — L.A.M. 305, 305A, 318. S.D. 5. U.C.L.A. 294, 295.

Original description. — Shell lenticular, with coarse concentric striae; posterior extremity direct; lunule small, elliptical, impressed, transversely striated, prominent in the right valve, and fitting into a corresponding depression in the left; cardinal and lateral teeth prominent. (Conrad.)

The lunule in the shell is remarkable for forming a distinct tooth, and the shell is destitute of a fold. (Conrad.)

Remarks. — Several valves of this species are in the collections from near the Mexican boundary. Small valves up to 9 mm in length are very elongated. The largest valve from Loc. 305 (LAM) is 19.5 mm long. Two small right valves from the south slope of Mount Soledad, are in the collection of the San Diego Society of Natural History. The larger one is 13.6 mm long, 13.7 mm high, convexity, 4.2 mm. A large Recent specimen collected at San Diego by Henry Hemphill is 35.9 mm long, 34 mm high, the convexity (both valves together), 19 mm. The hinge of this species has been illustrated by Chavan (731).

The shell of this species is easily separable from that of other species of *Lucina* occurring in Pliocene beds in California by the complete lack of any depressed area either posteriorly or anteriorly, concentric sculpture only, and in the character of the lunule which lies entirely in the right valve.

The species described as *Lucina* (*Myrtea*) *nipponica* Nomura and Hatai (732) from beds of middle Miocene age in Japan was compared with *L. californica*. The Japanese species was said to differ in the smaller size, finer sculpture, and in the somewhat different outline.

Lucina californica is known to occur in beds of late Pliocene age on Cedros Island, Lower California, from Fourth and Broadway streets in Los Angeles, and the present record adds its occurrence in the San Diego Formation. Gale (733) recorded it with question in the lower zone in the Frutivale district in the San Joaquin Valley in strata of late Miocene age. However, Grant and Gale in their later work (1931) made no mention of this record. It occurs commonly in Pleistocene deposits in southern California and northern Lower California as well as Recent.

SUBGENUS PARVILUCINA DALL

Parvilucina Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, p. 906, August 22, 1901. "Type, *Lucina tenuisculpta* Carpenter." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1362, 1903. Type, *Lucina tenuisculpta* Carpenter. — Woodring, Carnegie Inst. Washington, Publ. 366, p. 125, 1925. Type as designated by Dall. — Chavan, Jour. de Conchyl., Vol. 81, No. 3, p. 208, 1937. Genotype, *Lucina tenuisculpta* Carpenter.

Type species (by original designation). — *Lucina tenuisculpta* Carpenter [Rept. Brit. Assoc. Adv. Sci., for 1863, p. 642, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 128, 1872. Cited from "Puget's Sound and the neighbourhood" and the region between San Diego and San Pedro, also the Santa Barbara Islands. "4 fm. living, Cp." The island variety, 120 fms. Illustrated by Dall, 1901, p. 828, pl. 40, fig. 5, 1901. — Chavan, 1937, p. 209, fig. 4. — K. V. W. Palmer, Geol. Soc. Amer. Mem. 76, p. 86, pl. 8, figs. 8-12, 1958. (Holotype).]

Range. — Late Cretaceous (Senonian) (Chavan, Treatise on Invert. Paleo., Pt. N, Moll. 6, Bivalvia, Vol. 2, p. N498, 1969); mid-Eocene to Recent, North America (Woodring). Recent from the intertidal zone to 525 meters (287 fathoms).

Original description. — Shell small, plump, often inequilateral; sculpture more or less reticulate but not muricate, teeth small, but all usually present. For *Parvilucina* s. s.: Dorsal areas obscure or obsolete, sculpture feeble. (Dall.)

Remarks. — This subgenus is represented in the late Cenozoic of western North America by two species and a subspecies, the latter occurs in the San Diego Formation.

A subgenus *Callucinella* Chavan (734) was described as differing from *Parvilucina* in the larger size, irregular concentric sculpture, very fine crenulations on the margin, and longer lunule. The hinge also differs from *Parvilucina*, among other features, in the presence of a lateral lamella and in the elongated cardinal teeth, especially the posterior ones.

Lucina (*Parvilucina*) *tenuisculpta intensa* Dall

Plate 46, Figures 6, 7, 17, 22

Lucina tenuisculpta Carpenter, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. Well at San Diego, California, Pliocene. — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. From "well-digging in stratum B²", San Diego, Pliocene. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, p. 48, 1944. Dall's record (1874) cited.

Not *Lucina tenuisculpta* Carpenter.

Phacoides (*Parvilucina*) *intensus* Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1385, pl. 50, fig. 8, October, 1903. — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. No. 53, Pt. 1, p. 497, 1905. Original locality cited. — Keen and Benton, Geol. Soc. Amer., Spec. Papers No. 56, p. 98, 1944. Original locality record cited.

Phacoides intensus Dall, Arnold, Smithsonian Misc. Coll. (Quart. issue), Vol. 50, Pt. 4, pp. 423, 445, pl. 56, figs. 9a, 9b, 1907. One mile north of Schumann; "Waldorf asphalt mine". "Found in lower Pliocene as far south as San Diego." — Arnold, U. S. G. S., Bull. 322, pp. 59, 148, pl. 23, figs. 9a, 9b, 1907. [Same locality information as in preceding reference.] — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 288, 1931. [In synon. of *Lucina* (*Myrtea*) *tenuisculpta* Carpenter]. Dall's record (1874) cited. — Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 222, p. 86, 1950. "Pliocene strata encountered in a well at San Diego."

Type specimen. — No. 135041, United States National Museum.

Type locality. — "Pliocene of San Diego, California, from a depth of one hundred and sixty feet below the surface in the city park well; Hemphill."

Range. — Middle and late Pliocene in southern California.

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 305, 305A, 318, 319. U.C.L.A. 294.

Original description. — Shell small, resembling *P. tenuisculptus* Cpr., but with the concentric sculpture

much sharper though very fine, the radials feeble, the lunule large, lanceolate, and impressed, the beaks small and prominent, the hinge very delicate, the posterior dorsal area with a wide, shallow sulcus, and the inner margins rather coarsely crenulate. Alt. 4.5 mm, long. 5.0 mm, diam. 3.0 mm. (Dall, 1903.)

Remarks. — Five valves from the original lot collected by Henry Hemphill from which the type of this species was described are in the type collection in the Department of Geology of the California Academy of Sciences. The largest, a left valve, is approximately 8 mm long, 6.4 mm high, convexity, 3.4 mm. The other valves in the collection are much smaller.

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 957, 1135, 1178, 1181, 1182, 1183, 1186, 1399, 1400, 1401, 1402, 1413, 1415, 1418, 1419, 12053. L.A.M. 104, 107, 122, 305, 305A, 319, A-1323. S.D. 34, 38, 79, 150, 331, 365, 2930. U.C.L.A. 294, 295, 2359.

Original description. — Shell orbicular, rather flattened, inequilateral, concentrically laminately ridged, ridges sharp, erect, interstices concentrically striated, lunule lanceolately ovate, rather deeply excavated; semi-transparent white. (Reeve.)

Remarks. — This species is encountered rather commonly in the San Diego Formation. It is easily recognized by its rounded form, nearly straight posterior dorsal margin and well developed and well spaced (about 2.5 to 3 mm apart) concentric lamellar sculpture.

We have observed about 30 valves and a number of casts of this species from the San Diego Formation. The largest valve, from Loc. 305 (LAM), is 61.6 mm long and 57 mm high. Young specimens have a weak anterior lateral tooth.

Some writers have considered this species to be identical with *Lucina acutilineata* Conrad (721) which was originally described from beds of Miocene age at Astoria, Oregon. The length was given as 1 1/2 inches, the height slightly less than the length and the "thickness 45/100 L." Stewart (722) examined Conrad's type specimen and stated that it has a shorter posterior dorsal margin than that of Recent *L. annulata*. Woodring (723) also recognized this difference between the two, mentioned that Miocene specimens are usually smaller than Recent shells and designated a specimen as lectotype of *L. acutilineata*. A Recent specimen of *L. annulata* from Loc. 34051 (CAS), dredged in 165 meters (90 fathoms) off Gaviota, California, is 73 mm long and 66 mm high.

Dall's (724) diagnosis of "*Phacoides acutilineatus*" was based upon a somewhat worn specimen of Pliocene age from Coos Bay, Oregon, and may not be referable to Conrad's species.

The generally longer posterior dorsal margin, much greater size, and hinge characters of the Pliocene and Recent shells, justify assigning them to *Lucina annulata* with the status of a distinct species.

Lucina annulata desirata Dall (725) was described as differing from the typical form in the more steeply sloping posterior dorsal margin and in that the primary concentric lamellae are more irregularly spaced.

The species described as *Phacoides columbianum* Clark and Arnold (726), closely resembles *L. acutilineata* but it was said to differ in lacking a posterior depressed area and in possessing an anterior lateral tooth on the

hinge of the left valve.

Lucina hannibali Clark (727), which occurs commonly in the Blakely Formation of Washington and in beds of equivalent age in Alaska and Japan, is characterized by the attenuated anterior portion of the shell.

Two Recent species occurring in west American waters, *Lucina aequizonata* Stearns and *L. heroicus* Dall, have more steeply sloping dorsal margins and thus differ in outline from *L. annulata*.

Lucina annulata has been recorded (728) occurring in Japanese waters from 31° to 41° North latitude and several similar species occur as fossils in strata of late Tertiary age in the same region.

Over a hundred and fifty valves are in the collections of the Los Angeles County Museum from near the Mexican boundary. The largest one, from Loc. 319 (LAM), is 8 mm long.

These valves differ from Recent specimens of *Lucina (Parvilucina) tenuisculpta* Carpenter (735) chiefly in their smaller size, stronger concentric sculpture and in the larger lunule. Large specimens of *L. tenuisculpta* from Port Orchard, Puget Sound, are 11 mm long and 10 mm high; and Woodring mentioned specimens of this species which are 14 mm long.

Woodring believed that the apparent stronger concentric sculpture of *Lucina intensa* mentioned by Dall in comparison with Carpenter's species may be due to erosion of the early portions of Recent shells of *L. tenuisculpta*. The consistently smaller size of the Pliocene fossils together with the larger lunule, and at least in the type series, stronger concentric sculpture leads us, at least for the present, to assign subspecific status to the form described by Dall.

Lucina (Parvilucina) approximata Dall (736) described from the Gulf of California bears some similarity to *L. tenuisculpta intensa*, but it has much stronger radial sculpture.

GENUS *MILTHA* H. AND A. ADAMS

Miltha H. and A. Adams, Gen. Rec. Moll., Vol. 2, p. 468, April 1857. Sole species, *Lucina (Miltha) childreni* Gray. — Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 88, November, 1953. Type by monotypy. — Vokes, Tulane Studies Geol. Paleo., Vol. 7, No. 3, p. 95, December 29, 1969. Type by monotypy.

Type species (by monotypy). — *Lucina (Miltha) childreni* Gray [= *Lucina childrinae* Gray, Zool. Jour., Vol. 1, No. 2, p. 221, footnote, June, 1824. No locality cited. (In errata, "for *childrinae*, read *childreni*."] — Gray, Ann. Philos., New Ser., Vol. 9, p. 136, February, 1825 (as *Lucina childrinae*). "Brazile". — Reeve, Conch. Icon., Vol. 6, *Lucina*, sp. 12, pl. 3, fig. 12, 1850 (as *Lucina childreni*). "Brazile." — Wilkins, Bull. Brit. Mus. (Nat. Hist.), Historical Ser., Vol. 1, No. 4, p. 159, pl. 23, fig. 6, March, 1957. "From Brazil." "Lectotype." — Vokes, 1969, p. 116, pl. 1, fig. 1; pl. 2, figs. 1a, b; pl. 4, figs. 1-4 (as *Miltha (Miltha) childrinae*).

Range. — Eocene to Recent. East and west coasts of the Americas (*Miltha*, s. s.). Recent from 33 to 101 meters (18 to 55 fathoms). Also reported from the late

Tertiary of Australia and New Zealand.

Description. — Shell subovate to subelliptical with a fine to coarse concentric sculpture. Lunule asymmetrical, larger in the left valve and generally transgressing across the valve margin into the interior. Ligament large, external, immersed. Anterior adductor scar very long and narrow, near or quite widely separated from the pallial line which is parallel. (Olsson and Harbison.)

The hinge of *Miltha* has two teeth in each valve but laterals are lacking.

Remarks. — The large suborbicular, depressed inequivalve lucinids referred to *Miltha s. s.* appear to be limited to the American region during both past and present time.

Several groups of species formerly cited under *Miltha* have been placed under separate subgenera. *Pseudomiltha* Fische (737), an Eocene-Oligocene group has a virtually edentulous hinge. *Eomiltha* Cossman (738), Eocene to Recent, differs from *Miltha* in that it is more produced anteriorly, the pallial line is close to the margin, the anterior adductor impression is narrower, longer, and farther from the pallial line and the hinge lacks anterior lateral-like ridges. *Plastomiltha* Stewart (739) is said to differ from *Miltha* in the deeper lunule, smaller cardinal teeth, and in that the anterior adductor impression is narrower. Olsson and Harbison (1953, pp. 83-84) consider that subgenus to be confined to beds of Eocene age and they consider it to be more closely related to "*Phacoides*" than to *Miltha*. *Armimiltha* Olsson and Harbison (740) based upon *Lucina disciformis* Heilprin, a Pliocene species, is said to differ from *Miltha* in the much stronger sculpture and from *Plastomiltha* by the larger lunule which with growth partially effaces the cardinal teeth, the larger of which is double.

Species of *Miltha s. s.* inhabit tropical or subtropical waters at the present time and apparently this also was true of the fossil forms of this group. Species referred to this and related subgenera (or genera) lived in widely separated regions of the world during later Tertiary time. Species have been described from California and Lower California, Peru, Argentina, Florida, and New Zealand. The distribution of *Miltha* in the later Tertiary of south-eastern Australia was discussed by Wilkins (741). A recent paper by Vokes (742) contains a comprehensive account of the genus *Miltha* and of the Neogene species in Florida.

During early Miocene time in western North America *Miltha s. s.* ranged as far north as Santa Cruz Co., California. During Pliocene time it occurred as far north as San Benito Co., whereas during succeeding Pleistocene time it is known with certainty to occur only as far north as Magdalena Bay on the west coast of Lower California.

Khomenko (743) recorded a species assigned to this genus from beds of the Matchgar section, middle Miocene, in the Schmidt Peninsula, Kamtschatka, but we have not seen specimens from that region.

Recent species of *Miltha s. s.* now live only in waters of Brazil and the Gulf of California.

SUBGENUS *MILTHA* S. S.

Miltha (Miltha) xantusi Dall
Plate 45, Figures 14-17

Phacoides (Miltha) childreni Gray, Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, p. 812, 1901. "Gulf of California, Cape St. Lucas, Mazatlan."

Not *Lucina childrinae* Gray, 1824. (*Lucina childrenae* Gray, 1824).

Phacoides (Miltha) xantusi Dall, Nautilus, Vol. 18, No. 10, p. 111, February 1905. "Cape St. Lucas."

Phacoides sanctaerucis Arnold, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 167, 174, 1912. "San Diego-Purisima." Pliocene.

Not *Phacoides (Miltha) sanctaerucis* Arnold, 1909 (1910).

Phacoides xantusi Dall, Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, pp. 84, 85, 1929. "San Diego Pliocene."

Lucina (Miltha) xantusi Dall, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 291, pl. 14, figs. 20a, 20b (middle Pliocene of Holser Canyon, Los Angeles Co.), 1931. [Not all the synonymy.] — Hertlein and Strong, Zoologica, Vol. 31, Pt. 3, p. 115, pl. 1, fig. 13, 1946. Cape San Lucas, Lower California, Arena Bank, Gulf of California, Recent.

Miltha xantusi Dall, Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 77, pl. 19, figs. 3, 8, 1950. Coronado Island, Gulf of California, Pleistocene. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 215, pl. 30, fig. 4, 1961. Lower California. — Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 40, pl. 18, figs. e, f, 1968. Balboa Park, San Diego, Pliocene.

Miltha (Miltha) xantusi Dall, Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 98, fig. 198, 1958. Taken mostly off Cape San Lucas, Lower California, in 30 or more fathoms.

Type specimen. — No. 5383, United States National Museum.

Type locality. — "Cape St. Lucas," Lower California, Mexico.

Range. — Late Miocene (Castaic Formation) (744), to Recent. Recent, Cabo Haro, west of Guyamas Bay, Sonora, to Mazatlan, Sinaloa, and La Paz to Cape San Lucas, Lower California, Mexico, in 33 to 101 meters (18 to 55 fathoms).

Occurrence in San Diego Fm. — C.A.S. 1401, 1402. L.A.M. 302, 305, 305A, P.87. S.D. 29, 61, 80, 5251. U.C.L.A. 2359.

Original description. — "The *P. xantusi* seems to be a smaller species when adult, more rounded, more equivalved and with a shorter ligament. It has a more or less bifurcate and vermiculate radial sculpture, that of *P. childreni* being finer, more regular and more distinctly divided into fine continuous radial grooves and a microscopic minor sculpture between them.

"As in many other Lucinacea, directly under the beaks there is a small impressed area. In *P. xantusi* this in the right valve projects so as to fill an excavation in the other valve and is so much impressed as to make the beak appear sharper and more produced and to distinctly arcuate the two cardinal teeth. . . . In the California species the lunule is very small and bent vertically downward so that in the closed valves it is excavated and not projecting and has a length of about 6 mm. It is almost wholly confined to the right valve." Measurements: height, 71 mm, width 65 mm. (Dall, 1905.)

Remarks. — A large series of specimens referable to the present species is represented in the collections from

Balboa Park and Mount Soledad. These agree in all observable details with a Recent specimen from the Gulf of California illustrated by Hertlein and Strong as well as with fossil specimens from Pleistocene beds in the Gulf of California region such as illustrated by Durham. One of the largest specimens is 72 mm high, 67 mm long, the convexity (both valves together), 26.4 mm. A more rounded specimen is 68.5 mm high, 69.6 mm long, convexity, 22.4 mm (both valves together). A specimen from Loc. P. 87 (LAM), Reynard Way, San Diego, is 63 mm long, 63 mm high, convexity, 21.5 mm.

There is considerable variation in shape and in the degree of convexity. Young shells are generally more rounded in outline. Many shells, especially large ones, are elongated from beak to base. The left valve is usually flatter than the right, but in some specimens the valves are of nearly equal convexity, and occasionally the left valve may be the more convex of the two. The lunule as described by Dall is mostly in the right valve, is impressed, and is about 6 mm in length. On some specimens a submedian slight depression or faint broad groove extends from the umbo to the base, but on others it is lacking. The right valve has two cardinal teeth, slightly grooved in large specimens, the left valve with a shorter anterior cardinal and a posterior cardinal (sometimes faintly grooved) and a long posterior nymph. The interior of the valves sometimes bears fine pits, in others the interior may be thickened in part with shell material. The margins are smooth. Externally the surface is sculptured with concentric lines of growth, occasionally with deeper grooves and often with faint radial lines visible, especially on the medial portion of the valves. Recent shells are pure white.

This species was cited in the earlier literature under the name of *Lucina* or *Miltha childreni* Gray, the type of the genus *Miltha*, which occurs in Brazil. Dall, in 1901, cited it from the Gulf of California under the name of *Phacoides (Miltha) childreni* Gray. In 1903 he cited it as occurring in beds of Pliocene age at San Juan in the Gulf of California. Two years later he described the Recent species in the Gulf of California as *Phacoides (Miltha) xantusi*, and the fossil form from San Juan was described as *Phacoides joannis* (745). According to Dall, this Pliocene form "resembles the Recent *P. xantusi* in having the folded lunule, only, in this case, the margin is more deeply infolded and the shell heavier, more elongate-oval, and about one-fourth smaller. It measures 55 mm in height by 51 mm in width; *P. xantusi*, 71 x 65 mm, and *P. childreni*, 86 x 77 mm."

We have examined a cast of the type of *Phacoides joannis*, a left valve. The impressed lunular area on this specimen may be slightly deeper than that on *M. xantusi*, and the interior of the shell appears to be nearly filled with shell material. However, in all other particulars it agrees with specimens of *M. xantusi* of the same size. We are inclined to consider *M. joannis* to be referable to the Recent species, *M. xantusi*.

Phacoides (Miltha) sanctaerucis Arnold (746) was described from strata of early Miocene age in the "reef bed" in the Devil's Den district, Kern Co., California. Arnold mentioned that his species "is characterized by its large size, circular outline, slight angulation dorsally, compressed disk, prominent lunule and dorsal areas, and finely concentrically striate but otherwise unsculptured surface." He stated that it is closely allied to the Recent

species in the Gulf of California "but may be distinguished by its shorter lunule and relatively greater breadth."

We have examined a cast of the type specimen of Arnold's species. The valves are thick, nearly equal in convexity and decidedly circular in outline. There is variation in the series of specimens of this species from beds of Miocene age, but in general the valves appear to be thicker, more nearly equal in convexity and more circular in outline in comparison with Recent and fossil specimens of *Miltha xantusi*. We are inclined, at least for the present, therefore, to retain *M. sanctaerucis* as a distinct species.

Stoliczka (747) mentioned that the Cretaceous species described by Pictet and Campiche as *Lucina sanctaerucis* (748) "may belong to *Mysia* rather than to *Lucina*." Fortunately, the original assignment of Arnold's species to the genus *Phacoides* avoids invalidation as a homonym of the European species.

The resemblance of *Miltha pacifica* Olsson (749), described from strata of Miocene age in Peru, to *M. sanctaerucis* Arnold was pointed out by Olsson. *Miltha s. s.* is also represented in Argentina by *M. inheringiana* Doello-Jurado (750) described from beds of the Entremont Formation of probable Miocene age.

Miltha neozealanica Marshall and Murdoch (751), described from late Tertiary beds in New Zealand, was said to resemble closely *M. sanctaerucis* Arnold. This New Zealand species was made the type of *Milthoidea* Marwick (752), but according to Chavan, and Ludbrook (753), Marwick's genus can be placed in the synonymy of *Miltha s. s.*

Probably most of the records of *Miltha sanctaerucis* from beds of Pliocene age in southern California are referable to *M. xantusi*. However, some specimens (754) from Pliocene beds in Imperial Co. do resemble Arnold's species.

Miltha xantusi is known to occur in Pliocene and Pleistocene beds in the Gulf of California region and in Pleistocene beds at Magdalena Bay, Lower California, where it was recorded by E. K. Jordan (755). This species, under the name of *Miltha childreni*, was reported by J. P. Smith (756) as occurring in strata of late Pleistocene age at San Pedro, California, but later workers have not mentioned it from those beds.

FAMILY DIPLODONTIDAE DALL (757)

Shells of this family are generally small (length up to about 40 mm), suborbicular to subtrigonal, convex or depressed, thin, white. Surface smooth or sculptured with fine growth lines, often minutely punctate or coarsely granulose. Ligament external but sometimes becoming partly immersed below the margin and attached to a flattened nymphal plate. Hinge with two cardinal teeth in each valve, of which the left anterior and the right posterior tooth are typically double or bifid. Adductor scars subequal in size and connected by an entire pallial line which is often wide and ribbon-like. [Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst., Ithaca, New York), p. 199, 1961.] Cretaceous to Recent.

Remarks. — As mentioned by Olsson, the subequal muscle impressions (the anterior one longer and narrower)

and double cardinal teeth of the hinge, as well as anatomical characters, are features in which the Diplodontidae differ from the Lucinidae.

Chavan (758) recently discussed the classification of this family. The subgenera *Diplodonta* s. s. and *Felaniella* are each represented by one species in the San Diego Formation.

GENUS *DIPLODONTA* BRONN

Diplodonta Bronn, Italiens Tertiär-Gebilde und deren organische Einschlüsse (Heidelberg), pp. IX, 96, p. XII (as "*Diglodonta*" (typ. err.), 1831. [Concerning the date of issue of this work see Bowden and Heppel, Jour. Conch., Vol. 26, No. 2, p. 109, Note 4, 1966.] Species cited: "*D. lupinus* nob. (*Venus lupinus* Brocchi l.c.II.p. 553. Taff. XIV. fig. 8.)" and "*D. trigonula* n. sp." — Gardner, U. S. G. S., Prof. Paper 199-A, p. 79, 1943. Type as designated by Herrmannsen. — Eames, Phil. Trans. Roy. Soc. London, Ser. B, No. 627, Vol. 235, p. 378, 1951. (With Synon.). "Type species: *Venus lupinus* Brocchi, (non Linné). . ." — Chavan, Bull. Inst. Roy. Sci. Nat. Belgique, Tome 38, No. 23, p. 8, 1962. Type as indicated by Herrmannsen, "*Venus lupinus* Brocchi, 1814, (p. 553) non Linné = *Tellina rotundata* Montague, 1803 (p. 77, pl. II, Fig. 3) = var. *aequilateralis* Ceruelli, 1909."

Type species (designated by Herrmannsen, Indic. Gen. Malacozoorum, Bd. 1, p. 392, 1846). — "Typus: *Venus lupinus* Brocchi." [*Venus lupinus* Brocchi, Conch. Foss. Subapennina, Vol. 2, p. 553, pl. 14, fig. 8, 1814. "Abita nell' Adriatico (Ren.). Fossile in Valle di Andonae nel Piacentino." Italy, Pliocene. Illustrated by Bronn, Lethaea Geognostica, Bd. 3, p. 391, atlas, pl. 37, figs. 18a, b, c, 1853-1856. — Woodward, Man. Moll., ed. 4 (reprint), p. 458, pl. 19, fig. 9, 1910. "Miocene, Turin." — Chavan, 1962, p. 8, fig. 3.]

Range. — Cretaceous to Recent. Recent, from the intertidal zone to 1360 meters (744 fathoms).

Description. — Shell equivalve, not gaping, subcircular, the beaks subcentral and not prominent. Lunule and escutcheon not defined. External surface smooth or incrementally sculptured. Ligament chiefly external, supported on marginal nymphs. Hinge of right valve armed with a simple anterior and a bifid posterior cardinal; hinge of left valve armed with a bifid anterior and a simple posterior cardinal, so that in the closed valves the two outer cardinals are simple, the two inner ones bifid. Laterals absent. Adductor impressions oval, the anterior longer and narrower than the posterior. Pallial line entire. Inner margins of valves smooth. (Gardner, 1943.)

Remarks. — Nine species of *Diplodonta* have been reported from strata of Tertiary age in California. Five species have been recorded living in marine waters between Bering Sea and San Diego, California, and eleven species have been reported from tropical and subtropical west American waters.

The genus is widespread and is represented by about 50 species in the seas at the present time. The greater number of species occur in warm waters. Most of these occur in quite shallow waters but at least one species, *Diplodonta* (*Felania*) *rosca* Reclúz, in the South Atlantic, was reported by Thiele and Jaekel to occur at a depth

of 155 meters. Lamy (759) published a paper dealing with the Recent species of *Diplodonta* in the collections of the Natural History Museum in Paris.

The genus name *Taras* Risso has been used by some authors instead of *Diplodonta* Bronn. Prashad (760) doubted that the type species of *Taras*, *T. antiquata* Risso, is even a member of the family Ungulinidae [=Diplodontidae] and Chavan (761) later discussed this question and gave good reasons for abandoning usage of *Taras* in favor of *Diplodonta*.

Key to Subgenera of *Diplodonta* (762)

- A. Subglobose, nearly equilateral; white. *Diplodonta* s. s.
- B. Compressed, inequilateral; usually covered by a dark periostracum. . . . *Felaniella*

SUBGENUS *DIPLODONTA* S. S.

Diplodonta (*Diplodonta*) *orbella* Gould
Plate 55, Figure 11; Plate 57, Figures 9, 18

Lucina orbella Gould, Proc. Boston Soc. Nat. Hist., Vol. 4, p. 90, November, 1851. — Gould, Boston Jour. Nat. Hist., Vol. 6, p. 395, pl. 15, fig. 3 [two figs.], 1853.

Diplodonta orbella Gould, Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 238, 1888. "Pl. — San Diego well." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 134, pl. 18, figs. 8, 8a, 1903. (Lower San Pedro series, Deadman Island), 1903. "Pliocene. — San Diego well (Dall)." — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 38, pl. 3, fig. 4; pl. 25, figs. 5 and 6 (copy of Gould, 1853, pl. 16, fig. 3), 1924. Puget Sound to the Gulf of California. [Not the record from Bering Sea.] — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 124, pl. 6, figs. 5, 6, 1924. (Reproduction of figures by Gould, 1853). "Type locality, San Diego, California." "Range. Pribiloff Islands to the Gulf of California." [Not the record "Pribiloff Islands." — Haas, Field Mus. Nat. Hist., Zool. Ser., Vol. 29, No. 1, pp. 8-12, figs. 3-7, 1943. La Jolla and Terminal Island, San Pedro, California. Recent. *Taras orbellus* Gould, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 293, pl. 14, figs. 14a, 14b (Recent), 1931. "San Diego well, Balboa Park, San Diego (Dall)." Pliocene.

Type specimen. — No. 169271, Museum of Comparative Zoology, Harvard University (Johnson, U. S. Nat. Mus., Bull. 239, p. 119, 1964).

Type locality. — "San Diego, Lieut. Green." [California.]

Range. — "cf." Early Miocene; Pliocene to Recent. Recent from Monterey, California, to Punta Peñasco, Sonora, Mexico, in the Gulf of California, from low tide to 110 meters (60 fathoms), commonly nestling in holes in rocks, sometimes embedded in a "nest" which it builds.

Occurrence in San Diego Fm. — San Diego well (Cooper). L.A.M. 107, 305.

Original description. — *T. parva*, subglobosa, tenuicula, albidia, concentricè inequiliter striata; apicibus medianis, haud eminentibus, absque lunulâ anticâ; lateribus ferè symmetricis; intus alba. Cardo valvae dextrae dentibus duobus quorum antico minore — valvae sinistrae dentibus duobus quorum antico bifido, postico perobliquo, instructus; dentibus lateralibus nullis; cicatricibus leviter impressis, palleali serie punctorum composito. Long. 4/5; alt. 6/8; lat. 1/2-5/8 poll. (Gould.)

Remarks. — Chavan (763) suggested that the present species might be referable to the subgenus *Timothyus* Harris and Palmer (764), the type of which is a species of late Eocene age.

Diplodonta orbella was cited by Cooper as occurring in the collection from the San Diego well and this record is apparently the basis upon which records from that locality (referred to Dall) were cited by later authors.

Two casts retaining traces of shell are present in the collection from Loc. 107 (LAM), the clay quarry at the end of Arroyo Drive. The larger one is 19.8 mm long, the convexity (one valve), 7.5 mm. The smaller one is 14.8 mm long. These agree so exactly in outline and convexity with Recent and fossil specimens of *Diplodonta orbella* that we identify them with that species.

Two right and one left valve, all incomplete, are present in the collection from Loc. 305 (LAM). The largest, a fragment of a highly convex right valve is 18.5 mm high.

A very large Recent specimen in the collections of the California Academy of Sciences, collected by Henry Hemphill at San Diego, California, is 34.5 mm long, 31.2 mm high, convexity (both valves together) 26 mm. They are more often about 25 to 30 mm in length.

Haas (765) discussed the "nest" building habit of this species by which it forms a protective covering of sand and mucus.

Diplodonta orbella has been recorded as occurring in beds of Pliocene age at other localities than San Diego, such as in the Pico and Merced formations. *Diplodonta griesensis* Effinger (766) described from beds of middle Oligocene age in western Washington was compared with *D. orbella* and may be a precursor of Gould's species. "*Diplodonta cf. orbella* Gould" was cited by Loel and Corey (767) from Vaqueros beds, early Miocene, and Temblor strata, middle Miocene in age, and Bremner (768) recorded it under the same heading (identification by Corey), from Temblor beds on Santa Cruz Island, California. Judging from the literature, there is an element of doubt connected with many of the records of *D. orbella* from pre-Pliocene strata. Khomenko (769) cited the occurrence of *D. orbella* in Matchgar beds of lower Miocene age on the Schmidt Peninsula on Kamtschatka, but this identification appears doubtful. Records of this species from Japan are referable to other species.

The exact northern range of Recent *Diplodonta orbella* is not known with certainty. We have not observed Recent specimens from north of Monterey, California. Some of the Alaskan shells formerly referred to this species are referable to *Diplodonta impolita* Berry (770). We have observed specimens of this species from as far south as Cordell Bank (Lat. 38° N.), west of Point Reyes, California, in 40 meters (22 fathoms). *Diplodonta impolita* differs from *D. orbella* in the narrower, less inflated and more pointed umbos, more steeply sloping

anterior dorsal margin, earthy texture and coarser incremental striae. Also the right anterior cardinal is vertically elongated in comparison to the analogous somewhat node-like tooth on Gould's species. Another northern form was described as *Diplodonta* (*Torelli* Jeffreys, var.?) *aleutica* by Dall (Proc. U.S. Nat. Mus., Vol. 23, p. 820, pl. 42, fig. 3, August 22, 1901) from Kyska Harbor, Aleutian Islands, in 8 fathoms.

SUBGENUS FELANIELLA DALL

Felaniella Dall, Jour. Conch., Vol. 9, No. 8, p. 244, October 1, 1899. "Type *Felania usta* Gld." — Lamy, Jour. de Conchyl., Vol. 65, No. 4, p. 338, 1921. "Type: *D. usta* Gould." — Habe, Gen. Jap. Shells, Pelecypoda, No. 2, p. 124, 1951. "Type species: *Felania usta* Gould (original designation)", figs. 256, 257.

Type species (by original designation). — *Felania usta* Gould [= *Mysia* (*Felania*) *usta* Gould, Proc. Boston Soc. Nat. Hist., Vol. 8, p. 31, March, 1861. "Inhabits Hakodadi Bay, in sandy mud, 8 fath." — Taki and Oyama, Paleo. Soc. Japan, Spec. Paper No. 2, p. 57, pl. 10, figs. 14-16; pl. 33, fig. 2, 1954 (as *Diplodonta* (*Felaniella*) *usta*). Japan. Pleistocene. — Kira, Col. Illus. Shells of Japan, p. 132, pl. 52, fig. 31, 1959 (as *Felaniella usta*.) Japan, Recent. — Chavan, Bull. Inst. Roy. Sci. Nat. Belgique, Vol. 38, No. 23, p. 10, 1962. Type: *Felania usta* Gould. Illustrated by Chavan, fig. 8. — Johnson, U. S. Nat. Mus., Bull. 239, p. 164, pl. 26, fig. 6, 1964 (as *Mysia* (*Felania*) *usta*.) Holotype].

Range. — Late Cretaceous to Recent (Chavan). Recent from the intertidal zone to 218 meters (119 fathoms).

Description. — Shell small, very inequilateral, slightly inflated; sculpture consisting of incrementals; ligament external; hinge of right valve consisting of a narrow anterior cardinal (3a) and a heavy, deeply bifid middle cardinal (3b); hinge of left valve consisting of a heavy, deeply bifid anterior cardinal (2) and a narrow posterior cardinal (4b). (Woodring, Carnegie Inst. Washington, Publ. No. 366, p. 130, p. 130, 1925.)

Remarks. — The shells of this subgenus differ from those of *Diplodonta s. s.* in that they are more compressed, less equilateral and in the Recent state they are covered with a dark periostracum.

Felaniella has been reported to range from Paleocene to Recent but in the western Americas it has not been reported earlier than in strata of Oligocene age (Tumey Sandstone). Most of the Recent species live in the Caribbean region and in the warmer waters of the eastern Pacific, but species also live in Japanese waters and one has been reported from South Africa.

Diplodonta (*Felaniella*) *cornea* Reeve Plate 43, Figures 7, 13, 20

Lucina cornea Reeve, Conch. Icon., Vol. 6, *Lucina*, species 25, pl. 9, fig. 25, June, 1850.

Lucina nitens Reeve, Conch. Icon., Vol. 6, *Lucina*, species 50, pl. 9, fig. 50, June, 1850. "Hab. Isle of Muerte,

Bay of Guayaquil (in sandy mud at a depth of about eleven fathoms); Cuming."

Lucina sericata Reeve, *Conch. Icon.*, Vol. 6, *Lucina*, species 55, pl. 9, fig. 55, June 1850. "Hab. — ?" — Adams and Reeve, *Zool. Voy. Samarang*, Moll., p. 80 p. 24, fig. 6, August, 1850. "Hab. Philippine Archipelago." [Locality believed to be erroneous.]

Diplodonta sericata Reeve, Woodring, Bramlette, and Kew, U. S. G. S., Prof. Paper 207, p. 83, pl. 36, figs. 11-14, 1946. Palos Verdes sand, San Pedro, California, Pleistocene.

Taras (Felaniella) sericatus Reeve, Hertlein and Strong, *Zoologica*, Vol. 31, Pt. 4, p. 131, pl. 1, fig. 10, 1947. "San Ignacio Lagoon, Lower California, to Guayaquil, Ecuador," Recent. [With synonymy.]

Diplodonta (Felaniella) sericata Reeve, Keen, *Sea Shells of Tropical West America* (Stanford Univ. Press: Stanford, California), p. 103, fig. 212, 1958. San Ignacio Lagoon, Lower California, to Ecuador.

Diplodonta (Felaniella) cornca Reeve, Olsson, *Mollusks of the Tropical Eastern Pacific* (Paleo. Res. Inst.: Ithaca, New York), p. 203, pl. 32, figs. 1, 1a, 1b, 1961. Gulf of California to Tumbes, Peru.

Type specimen. — Syntypes No. 1963 130/1-2, British Museum (Natural History).

Type locality. — "Hab. Gulf of Nicoya (in coarse sand at a depth of from ten to thirteen fathoms); Cuming." Costa Rica.

Range. — Middle Pliocene to Recent. Recent from San Ignacio Lagoon, Lower California, to Punta Peñasco in the Gulf of California, Mexico, and south to Tumbes, Peru, in 7 to 73 meters (4 to 40 fathoms).

Occurrence in San Diego Fm. — L.A.M. P. 87: S8443, 305.

Original description. — Shell *Cardium*-shaped, a little higher than long, rather depressed, no lunule, concentrically impressly striated, hinge with two central teeth in each valve, one of which is bifid; whitish, covered with a light olive shining horny epidermis. (Reeve.)

Remarks. — Four small, right valves and one left one, are present from Loc. 305 (LAM), near the Mexican boundary. The left valve is 10.5 mm long and 10.8 mm high. None of these valves is perfectly preserved but they agree in all observable details with Recent specimens of *D. cornca* of the same size. A fragment of a valve from the same locality, 17 mm long may be referable to this species.

One small right valve, slightly imperfect along the anterior margin, collected by Charles Sternberg in Balboa Park, is 11.5 mm long and 10.5 mm high.

A large Recent left valve from Loc. 27230 (CAS). Petatlan Bay, Mexico, is 22.6 mm long and 22.3 mm high. A specimen with paired valves from Loc. 23796 (CAS) Tepoca Bay, Gulf of California, is 20.5 mm long 20.2 mm high, convexity (both valves together) 9.6 mm. Another more convex specimen from the same locality is 19.2 mm long, 19.4 mm high, convexity (both valves together) 10.3 mm.

Diplodonta cornca is here reported for the first time from the San Diego Formation. It was reported (as *Diplodonta sericata*) by Emerson and Hertlein (*Trans. San Diego Soc. Nat. Hist.*, Vol. 13, No. 17, pp. 342, 349, 1964) from strata of Pliocene age on Carmen Island in the Gulf of California. It is well known from beds of

Pleistocene age in southern California and in Lower California and it has been reported (771) as a fossil from an elevated beach in Peru.

This species is generally recorded under the name *Diplodonta sericata* Reeve. Hertlein and Strong pointed out that *D. cornca* has page priority and this nomenclature was also adopted by Olsson. Furthermore *D. sericata* was originally described without information as to the locality from which it came. Later Adams and Reeve cited it from the Philippine Islands. Finally Carpenter and Dall, considered it to be a west American species. After consideration of the history of this species we conclude that it is best to use the earliest name applicable to this form.

The present species is very similar to *Diplodonta parilis* Conrad (772), described from Oregon in beds of middle Miocene age. Some authors have recorded *D. cornca* (as *D. sericata*) as a subspecies of *D. parilis*.

A series of specimens of *D. parilis* from Miocene strata at Loc. 166 (CAS), Clatskanie, Oregon, and casts of the specimens from the Astoria Formation in western Washington which were illustrated by Etherington (773), are all slightly more elongated anteriorly-posteriorly and the ends are a little more flattened than those of *D. cornca*. Some specimens from beds of late Pliocene age in San Joaquin Valley appear to be inseparable from *D. cornca*, others are hardly separable from *D. tellinoides* Reeve (774).

Diplodonta harfordi Anderson (775) described from beds of probable middle Miocene age in San Joaquin Valley has a straighter anterior dorsal margin than either *D. parilis* or *D. cornca*.

Diplodonta stephensoni Clark (776), described from the San Ramon Formation of late Oligocene or early Miocene age, near Walnut Creek, California, was said to differ from *D. "sericata"* [= *D. cornca*] in details of the hinge.

Diplodonta candeana d'Orbigny, originally described from Cuba, also is similar to *D. cornca*. Chavan (1962, p. 12) mentioned a resemblance between *D. "sericata"* [= *D. cornca*] and species in the subgenus *Zemysia* Finlay, 1927, with the type *Z. zelandica* Gray, 1835.

FAMILY THYASIRIDAE DALL (777)

Shell roundly trigonal, earthy, thin; posterior side with one or more radial depressions; ligament in a groove, partly external, hinge edentulous or in the right valve with a subobsolete pseudo-tooth; muscle impressions elongated; pallial line simple; margin smooth. Triassic (Chavan). Cretaceous to Recent.

Remarks. — This family is represented in the eastern Pacific by *Thyasira* and *Axinopsida*. One species of each is present in the San Diego Formation.

The greater number of species in this family live in boreal waters but a number of species are found in tropical waters.

The genus *Adontorhina* Berry (778) was placed tentatively, in the family Thyasiridae. However, the lack of a posterior radial depression, the hinge with ridged plates, and the granular or plated posterior dorsal margin, are shell characters differing from other members of this family.

Key to Genera of Thyasiridae

- A. Shell with one or more furrows
on posterior portion *Thyasira*
- B. Shell discoidal, lacking furrows
on posterior portion *Axinopsida*

GENUS *THYASIRA* LEACH IN LAMARCK

Thyasira Leach in Lamarck, Hist. Nat. Anim. s. Vert., Vol. 5, p. 492, July, 1818. Sole species cited, "*Thyasira flexuosa*. Leach." Ref. to "*Tellina flexuosa*. Maton Act. Soc. Linn. 8. p. 56, n. o. 16." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, Pt. 6, p. 1335, October, 1903. Sole species originally cited, *Tellina flexuosa* Montagu. — Lamy, Jour. de Conchyl., Vol. 65, No. 3, p. 290, 1921. Type, *Tellina flexuosa* Montagu. Fig. (p. 291).

Conchocele Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 27, February, 1866. Type (by virtual monotypy): *Conchocele disjuncta* Gabb, p. 28, pl. 7, figs. 48, 48a, 48b. "From Dead Man's Island, near San Pedro Bay; from a hard sandstone associated with two or three previously known Tertiary Fossils. Probably Miocene." [Late Pliocene or early Pleistocene.] [*Venus bisecta* Conrad mentioned in the text was considered as "probably belonging to this genus." This equivocal statement leaves *C. disjuncta* as the sole species available as type of the genus according to the present rules of nomenclature. For a discussion of this species, see Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 194, pl. 15, fig. 1, 1930. — Woodring, Bramlette, and Kew, U. S. G. S., Prof. Paper 207, p. 83, pl. 33, fig. 5, 1946. "*T. disjuncta* is the type of *Conchocele*."]]

Type species (by monotypy). — *Thyasira flexuosa* Montagu [= *Tellina flexuosa* Montagu, Test. Brit., p. 72, 1803, "It is plentiful in the sand of Falmouth harbour, and not uncommon on the south coast of Devonshire." Also, "Cornwall". Illustrated by Forbes and Hanley, Hist. Brit. Moll., Vol. 2, p. 54, pl. 35, fig. 4, 1852. — Jeffreys, Brit. Conch., Vol. 2, p. 247, pl. 5, fig. 6, 1863; Vol. 5, pl. 179, p. 33, figs. 1, 1a, 1869. — Thiele, Handbuch Syst. Weichtierkunde, Bd. 2, p. 864, 1935. See also Lamy, 1921, p. 292, fig. p. 291; Tebble, British Bivalve Shells [Brit. Mus. (Nat. Hist.)], pp. 16, 79, text-fig. 5a, 5b, 1966.]]

Range. — Cretaceous to Recent. Recent world wide from low tide to 10,004 meters (5470 fathoms) (779.)

Description. — Shell subcircular to subquadrate, moderately inflated, beaks strongly curved anteriorly; lunule consists of an impressed area below the beaks sometimes indistinct, escutcheon long and narrow; posterior side furrowed or sharply angulated; ligament usually partly external; sculpture of growth lines only; hinge lacking teeth but sometimes below the umbo of the left valve there is a fold in the hinge plate and behind this a slight projecting pseudo-tooth; muscle impressions lucinoid; pallial line simple; margins smooth.

Remarks. — The genus *Thyasira* occurs in western North America in strata of Cretaceous age and from

Oligocene to Recent, but no species have been described from beds of Eocene age in this region. One species has been recorded as occurring in the San Diego Formation. Popenoe (780) cited the occurrence of casts of "*Thyasira*" in brown, calcareous, silty sandstone dredged apparently on "Coronado Bank". Nothing further is known concerning the species represented by the casts or the age of the strata containing them.

This genus is represented by a number of Recent species and is widespread in the seas at the present time, mostly in cool waters. Many of the species are small or of moderate size, but a specimen of *T. disjuncta* collected by G. D. Hanna on the shore of Macleod Bay, Montague Island, Alaska, is 85 mm long, 69.5 mm high, and the convexity (both valves together) 55.4 mm. Hägg (781) cited a fossil form identified as *Thyasira bisecta* from beds of late Tertiary age in Spitzbergen, the largest of which was 85 mm long. Judging from the known records of size, Hägg concluded that this species attained a larger size in warmer rather than in very cold waters.

Most of the known living species of *Thyasira* were discussed or listed by Lamy (1921, pp. 289-318). Dall (782) mentioned nine species living in the eastern Pacific. A monographic study of this group would probably result in a reduction of this number. The Recent species living in New Zealand were given special attention by Fleming (783) who place *Prothyasira lredale*, 1930, in the synonymy of *Thyasira*. Antarctic species of this genus were discussed by Soot-Ryen (784). The Cenozoic species of *Thyasira* occurring in Japan were discussed by Yabe and Nomura (785) and species from the beds of Tertiary age in Sakhalin and Kamtschatka were described and illustrated by Slodkewitsch (786). Species of *Thyasira* of Cretaceous age from the western interior of North America were described and illustrated recently by Kauffman (787). In this paper he included a general discussion of this genus and its occurrence both Recent and as a fossil.

Thyasira gouldii Philippi
Plate 43, Figures 17, 21

Lucina flexuosa Montagu, Gould, Rept. Invert. Massachusetts (Cambridge), p. 71, fig. 52, 1841.

Not *Tellina flexuosa* Montagu, Test. Britannica; or Nat. Hist. British Shells, Pt. 1, p. 72, 1803. "Cornwall"; also "in the sand of Falmouth harbour" and "south coast of Devonshire."

[*Lucina*]. *Gouldii* Philippi, Zeitschr. f. Malakozool., Jahrg. 2, p. 75, May, 1845. [Description pp. 74-75. In a review of Gould's Report on the Invertebrata of Massachusetts.]]

Cryptodon Gouldii Philippi, Binney's edit. of Gould's Rept. Invert. Massachusetts (Wright and Potter: Boston), p. 100, fig. 52, 1870. Massachusetts Bay and neighboring region.

Cryptodon flexuosus Montagu, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "well at San Diego." "Pliocene." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. San Diego well. — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. Calif. State Mineral., p. 237, 1888. "San Diego well." — Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 85, 1889. Dall's record

(1874) cited. — Orcutt, quoted by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited.

Not Cryptodon flexuosus Montagu [= *Tellina flexuosa* Montagu, 1803].

Axinus gouldii Philippi, Sars, Bid. Kundsk. Norges Arktiske Fauna I, Moll. Reg. Arct. Norvegiae (Christiana) p. 60, pl. 19, figs. 6a, 6b, 1878. Various localities in northern Atlantic.

Thyasira gouldii Philippi, Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, pp. 786, 790, 1901. Greenland to Stonington, Connecticut, in 5 to 400 fathoms; on west coast from Metchigme Bay, Bering Strait, south to Puget Sound, in 8 to 11 fathoms. Also Pliocene of San Pedro, California. — I. S. Oldroyd Publ. Puget Sound Biol. Sta., Vol. 4, p. 37, pl. 42, fig. 5, 1924. "Bering Sea to San Diego, Calif.; Atlantic." [Reproduction of figure from Packard, 1918.] — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 120, pl. 34, fig. 5 (Recent). "Pliocene at San Diego well." Also other localities. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 282, 1931. "San Diego formation of the San Diego well in Balboa Park. San Diego (Dall, 1874)." — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) of *Cryptodon flexuosus* Montagu. — Morris, Field Guide to Shells (Houghton Mifflin Co.: Boston) p. 36, pl. 8, fig. 15, 1952. "from the Bering Sea to San Diego, California." — Ockelmann, Mar. Lamell., in Zool. East Greenland, Medd. om Grønland Vol. 122, No. 4, p. 100, pl. 2, figs. 4, 5, 1958. East Greenland and other localities in 2-3 to 385 meters Panarctic.

Thyasira gouldi Philippi, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 136, 1903. "San Diego well (Cooper)." — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 264, pl. 20 fig. 5, 1918. "Bering Strait to San Diego (Dall)."

Type specimen. — Reported to be in the State Museum, Albany, New York, by I. S. Oldroyd, 1924, but according to R. I. Johnson (written comm., October 27, 1964), no specimens of this species were found in any of Gould's collections examined by him.

Type locality. — "It inhabits deep water, and is very frequently taken from codfish, caught in Massachusetts Bay." (For "*Lucina flexuosa*" Montagu of Gould, 1841, not *Tellina flexuosa* Montagu, 1803.)

Range. — Pliocene to Recent. Recent from Bering Strait to San Diego, California, in 15 to 203 meters (8 to 111 fathoms). Atlantic from Greenland to Connecticut, in 9 to 732 meters (5 to 400 fathoms) Dall (1901); to North Carolina (Richards). According to Ockelmann (1961), this species "is uncommon at depth exceeding 100 m and even depths of about 50 m often only smaller specimens are found."

Occurrence in San Diego Fm. — San Diego well (Dall). L.A.M. 107, 305, 305A. U.C.L.A. 294.

Original description. — "Von *Lucina flexuosa* sagt Gould, p. 72: 'there can be no doubt, that this is identical with the British shell, though the specimens I have seen are much smaller, than the foreign specimens usually are'. Bei einer aufmerksamen Betrachtung findet man idessen, ausser dem sehr auffallenden Unterschied in der Grösse — die amerikanische Art ist 1 1/2", die englische 4"' gross

— folgende Verschiedenheiten: 1) die amerikanische Art ist schiefer, die hintere Seite, welche die beiden Falten trägt, kürzer; 2) dieselbe hat keine vertiefte Lunula, und ist namentlich den Schlossrand vorn nicht gerade oder selbst concav, sondern von Anbeginn an convex; dagegen geht 3) eine breite seichte Furche nach dem vordern Winkel hin, von der die englische Art keine Spur zeigt. Ich schlage vor, die amerikanische Art *L. Gouldii* zu nennen. Sie gehört übrigens in das Sowerby'sche Genus *Axinus*, welches mit dem Turton'schen Genus *Cryptodon* identisch ist, so wie mit dem von mir aufgestellten Genus *Ptychina*". (Philippi.)

Remarks. — This species was reported from the San Diego well by Dall in 1874. Subsequent records citing it from that locality apparently were based upon Dall's record. Seven fairly well preserved specimens in the collections of the University of California at Los Angeles, and a few others, mostly fragmental, in the collections of the Los Angeles County Museum, are from the San Diego Formation from near the Mexican boundary. The largest specimen from Loc. 294 (UCLA) is 9.4 mm long and 8 mm high. A Recent large left valve from Winter Harbor, British Columbia, in the collections of the California Academy of Sciences, is 9.6 mm long and 10.1 mm high.

These fossils appear to be identical with specimens of *Thyasira gouldii* from the Atlantic coast. Dr. A. M. Keen compared the fossils with Recent shells in the collection at Stanford University and concluded that *T. gouldii* could be considered to be a subspecies of the north European *T. flexuosa* Montagu. This was virtually the same opinion as that of Odhner (788) who noticed minor differences between the European species and specimens of *T. gouldii* from Alaska. The shell of the European species was said to be more fragile and white in comparison to Alaskan specimens of *T. gouldii* which were rougher, thicker and of a dirty white color.

The name *Lucina gouldii* was proposed by Philippi in 1845 (for "*Lucina flexuosa*" Montagu, described and illustrated by Gould) in a review of Gould's paper dealing with the Invertebrata of Massachusetts, 1841.

Binney (1870) stated that Philippi's criteria for separating *T. gouldii* from the European *T. flexuosa* are valid, namely, "ours is much smaller, more oblique, the hinder end on which the folds are situated is shorter, the lunule is less deep, and the anterior margin is not concave, but rather convex. Indeed the disparity in size is so great as scarcely to suggest a comparison."

A study of north Atlantic and Arctic species of *Thyasira* led Ockelmann (789) to believe that the east American forms described a *Cryptodon plana* Verrill and Bush (791) "must be regarded as junior synonyms of *T. gouldii* (Philippi)". Eyerdam's record of *T. gouldii* from Dryer Bay, Alaska, was later corrected to *T. cygna* Dall (792). The species from Japan cited under the name of *Thyasira gouldii* was named *Thyasira lokunagai* by Kuroda and Habe (793). According to Habe (794) the Japanese shell is smaller and has a narrower posterior flexure.

The group of *Thyasira flexuosa* (to which *T. gouldii* belongs) has been reported from Miocene to Recent in Europe. This group is widely distributed in the seas at the present time. *Cryptodon marionensis* E. A. Smith (795) from the Antarctic region was said by its author to be a southern form of *T. flexuosa* and *T.*

gouldii. Fleming (1950, p. 251) in his discussion of the Austral species, *T. peroniana*, stated: "It is indeed possible to consider *peroniana* and its races as subspecies of the wide-ranging *flexuosa* Mont."

Thyasira gouldii has been cited as occurring at several localities in beds of Pliocene age in southern California. Some of these occurrences are as follows: Potrero Canyon, 1/4 mile south of the Palisades post office, by Woodring (796); at Fourth and Broadway in Los Angeles by Soper and Grant (797); questionably at the Waldorf Asphalt Mine in the Foxen Mudstone in the Santa Maria district by Woodring (798). Woodring mentioned that the anterior end of specimens from that district is longer than on Recent specimens from California. *Thyasira gouldii* also has been recorded occurring in Pleistocene beds in California and Richards (799) has recorded it from beds of Pleistocene age in Maine, in Vermont, in Montreal, in Quebec, and in Newfoundland.

Valentine (800) considered *T. gouldii* to be a member of a "*Lucinoma annulata-Turcica caffee* community" in beds of Pleistocene age in southern California, deposited probably at a depth of 27 to 46 meters (15 to 25 fathoms). A "*Thyasira gouldii-Neptunea tabulata*" community is said to live in the "shallow outer sublittoral, 20-25 fathoms, silt and clay bottom."

Thyasira barbarensis Dall (801) appears to be quite distinct from *T. gouldii*. At the time of description of *T. barbarensis* Dall stated, "This fine species is nearer *C. sarsii* [802] than any other, but has decidedly more elevated and narrower beaks." He also included a description of the soft parts of his new species. Burch mentioned that *T. barbarensis* usually lives in colonies and Valentine (1961, p. 323) stated that it was found rather commonly on a mud bottom in 38-40 meters (21-22 fathoms) in Santa Monica Bay in southern California.

GENUS AXINOPSIDA KEEN AND CHAVAN

Axinopsis Sars, Bid. Kunds. Norges Fauna. I. Moll. Reg. Arctiae Norvegiae (Christiana), p. 63, 1878. Sole species, *Axinopsis orbiculata* Sars.

Not *Axinopsis* Tate, 1868, a new name for *Schizodus* King, 1844.

Axinopsida Keen and Chavan, in Chavan, Compt. Rend. Somm., Soc. Géol. Frane, No. 12, p. 210, June 18, 1951. "Type: *A. orbiculatus* Sars." — Keen, Min. Conch. Club South. California, No. 116, p. 4, December 1951. "Type (by original designation): *A. orbiculatus* (Sars)."

Type species (by original designation). — "Type: *A. orbiculatus* Sars" [= *Axinopsis orbiculata* Sars, 1878, p. 63, pl. 19, figs. 11a-d, "Vadsø paa 600-100 F. D." Also, from Vardø and Bodø, Norway. — Soot-Ryen, Norges Svalbard — og Ishavs — Undersøkelser, Medd. No. 43, p. 14, pl. 1, fig. 7, 1939. "Off East glacier, Cape Flora, 4 fathoms," and "Gunther Sound (Bay), 10 fathoms," Franz Josef Land. — Ockelmann, Medd. om Grønland, Bd. 122, No. 4, p. 111, pl. 2, figs. 7, 8, 1958. East Greenland and other localities. — MacGinitie, Proc. U. S. Nat. Mus., Vol. 109, No. 3412, p. 172, pl. 20, fig. 2, 1959. Pt. Barrow, Alaska, in 36 meters (120 feet).]

Range. — Middle Pliocene to Recent. Recent,

Arctic to Todos Santos Bay, Lower California, Mexico, and to Japan; Norway and Greenland to Cape Hatteras, North Carolina, in Atlantic; Antarctic, in 7 to 594 meters (4 to 325 fathoms). Cited from depths of 10,607 meters (5850 fathoms).

Description. — Shell discoidal, tumid in the middle, compressed towards the margins; umbones slightly prominent; no external ligament; valves thin, pellucid, white, concentrically striate; cardinal tooth in the right valve obtusely elevated, recurved, in the left valve elongated, subhorizontal; cartilage narrow. (For *Axinopsis*. Tryon, G. W., Jr., Structural and Systematic Conchology, Vol. 3, p. 216, 1884.)

Remarks. — The members of this genus live chiefly in Arctic and boreal waters but in the eastern Pacific this genus occurs south to Todos Santos Bay, Lower California, Mexico.

The shells of *Axinopsida* are small. The number of described species and subspecies is not large but the separation of the various forms has not been entirely satisfactory.

Genaxinus Iredale, type *Thyasira albigena* Hedley, is a similar genus but the hinge of species of this austral group is virtually edentulous (803).

Axinopsida serricata Carpenter

Plate 44, Figures 17, 18

Cryptodon serricatus Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 602, 643, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 88, 129, 1872. Indicated as from "Puget's Sound and the neighbourhood"; "Vancouver Island, Straits of S. Juan de Fuca, and adjoining shores of Washington Territory, formerly known as 'Oregon'." Also "Cat. Is. Cp. 120 fm." — Carpenter, Proc. Acad. Nat. Sci. Philadelphia, Vol. 17, p. 57, 1865. "Hab. — In sinu Pugetiano legit Kennerly: in insulâ Vancouver, Swannii Indianuli."

Axinopsis serricata Carpenter, Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1237, pp. 791, 819, pl. 40, fig. 2 (Puget Sound), 1901. "Kyska Island, Aleutians, south to Puget Sound and Catalina Island, California, in 2 to 120 fathoms." — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 38, pl. 26, fig. 4, 1924. Puget Sound; Departure Bay, British Columbia. Range: Aleutian Islands, Alaska, to Catalina Island, California. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 123, pl. 4, fig. 4, 1924. Range same as in preceding reference.

Axinopsida serricata Carpenter, K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 84, pl. 7, figs. 16-18, 1958. "Puget Sound, Washington (type)." Range same as given by Dall.

Type specimen. — "Lectotype. — U. S. National Museum, No. 5249" (Palmer, 1958.)

Type locality. — "Puget Sound, Washington (type)." (Palmer, 1958.)

Range. — Middle Pliocene to Recent. Recent from the Aleutian Islands, Alaska, to Todos Santos Bay, Lower California, in 4 to 219 meters (2 to 120 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A. Original description. — Small, circular, flat; epider-

mis silken. (Carpenter.)

Supplementary description: *C. t. parvâ*, subplanatâ, subcirculari tenui, albâ, haud flexuosâ; epidermide tenuissimâ, vix stramineâ, serricatâ, indutâ; laevi, seu lineis incrementi vix ornatâ, nitente; suborbiculari, seu ventraliter productâ; marginibus undique valde et regulariter rotundatis, regione lunulari incurvatâ; umbonibus attice hamatis; lunulâ planatâ, haud exacte difinitâ; intus, ligamento tenui, omnino celato; dentibus cardinalibus in utrâque valvâ uno, extante, lateralibus nullis; cicatricibus adductoribus subovalibus, haud prolongatis; lineâ palii à margine ahud crenato satis remotâ: Long. .16, lat. .18, alt. .1 (Carpenter, 1865.)

Remarks. — Three left and one small right valve of this species are present in the collection from Loc. 305 (LAM) from near the Mexican boundary. The largest of these, a left valve, is about 3.4 mm long and 3.1 mm high. The small right valve is higher than long. One right and two fragmental left valves are present in the collection from Loc. 305A (LAM).

The lectotype was described by Palmer as slightly higher than long, about 4.5 to 4 mm. Burch (804) questioned whether *Axinopsis viridis* Dall (805) could be separated from *A. serricata*. Dall illustrated two shells under these names and described *A. serricata* as "ovate" and *A. viridis* as "orbicular." Willett (806), and Woodring evidently believed that they could separate the two species on the basis of shape. Palmer (1958) however, pointed out that Carpenter originally described *A. serricata* as "circular." Furthermore in various collections she found specimens, some of which were round, others elongate, which were identified in some cases as *Axinopsis viridis* Dall and in others *A. serricata*.

We have examined Recent specimens from Alaska, Puget Sound, Monterey, and Redondo Beach, California. Most of these are circular in outline. A large one from Loc 18545 (CAS), Unalaska, is 3.9 mm long and high. Dall and others have indicated that the geographic ranges of *A. serricata* and *A. ovata* are nearly the same. We are inclined to share the doubts of Burch and Palmer that more than one species of *Axinopsida* lives in the north-eastern Pacific.

Axinopsis serricata was reported by Willett (807) from strata of late Pliocene age at Fourth and Broadway streets in Los Angeles; in the Lomita Marl, Hilltop Quarry, Los Angeles Co. (Valentine and Mead), and it also has been reported from beds of Pleistocene in age in British Columbia (808). *Axinopsida viridis* Dall was reported by Woodring (809) from the Waldorf asphalt mine in Santa Barbara Co. That species also has been reported from beds of late Pliocene age in Los Angeles Co. as well as in beds of Pleistocene age in Alaska, and at San Pedro, California.

SUPERFAMILY CARDIACEA OKEN (810) FAMILY CARDIIDAE OKEN (811)

Shell substance cellulo-crystalline, with the external layer more or less tubular; with a variable epidermis; valves equal free, gaping slightly behind, the beaks prosocoelous, the margins usually serrate or radially striated; adductor scars subequal, the pedal distinct and usually distant; ligament and resilium parivincular, external, set in a groove, short; area obscure; the complete armature of the hinge includes an anterior and posterior lateral in the left,

and two anterior and one posterior lateral in the right valve (any or all of which may be absent), the cardinal formula is L 1010, the teeth simple, smooth never bifid, R 0101

one cardinal in each valve usually persistent, the others inconstant. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 3, p. 549, 1895.). Late Triassic to Recent.

Remarks. — The members of this family are world-wide in distribution from the Arctic to the tropics in marine and in brackish water. A number of supraspecific units have been proposed for the members of the Cardiidae. These together with their type designations have been assembled in a paper by A. M. Keen (812)

Various papers concerning Cenozoic species of this family have been published. Among the more recent ones may be mentioned one by Marwick (813) dealing with the species of New Zealand, one by Tremlett (814) dealing with English Eocene and Oligocene species, and one by Sieber (815) dealing with Miocene species in the Vienna basin.

A synopsis of Recent west American species was published by Dall (816), and Hertlein and Strong (817), Keen (818), and Olsson (819) discussed many of the Recent tropical west American species. Notes by Burch (820) and others on the species occurring in the region between the Bering Sea and San Diego, California, occur in the Minutes of the Conchological Club of Southern California. A useful paper dealing with the species of Cardiidae living in the west Atlantic region was published by McLean (821).

Key to Genera and Subgenera of Cardiidae

- A. Shell large, with coarse radial ribs with roughly uniform secondary sculpture.
 - a. Beaks strongly prosogyrate . . . *Clinocardium*
 - aa. Beaks not prosogyrate or only slightly so.
 - b. Ribs lacking nodes . . . (subgenus) *Cardium* s. s. (822)
 - bb. Ribs in central portion bear elongated nodes on posterior and sometimes to a lesser degree on anterior side . . . (subgenus) *Dalloccardium*
- B. Shell small to moderate size, with rather fine radial ribs of which those on posterior fourth of valves differ in secondary sculpture . . . *Nemocardium*
 - a. Posterior ribs decidedly wider than the others . . . (subgenus) *Nemocardium* s. s. (822)
 - aa. Posterior ribs not decidedly wider than the others and crossed by concentric lamellae . . . (subgenus) *Keenaea*

GENUS CARDIUM LINNAEUS

Cardium Linnaeus, Syst. Nat., ed. 10, p. 678, 1758.
Cardium costatum Linnaeus, first of a number of

species described by Linnaeus. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1069, December, 1900. Earlier authors cited. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 302, 1931. Type (designated by Children): *Cardium costatum* Linnaeus.

Type species (designated by Children, Quart. Jour. Sci. Lit. Arts, Vol. 14, p. 315, pl. 6, fig. 59, 1823). — *Cardium costatum* Linnaeus [Syst. Nat., ed. 10, p. 678, 1758. "Habitat. . . ." Ref. to Rumphius, Mus., pl. 48, fig. 6; Gaultieri, Test., pl. 72, fig. D; Argenville, Conch., pl. 26, fig. A, and "Column. purp. 26, t. 27." Illustrated by Reeve, Conch. Icon., Vol. 2, *Cardium*, sp. 11, pl. 2, fig. 11, 1844. "Hab. East Coast of Africa." See discussion of this species by Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, art. 1, p. 54, 1952.]

Range. — *Cardium* s. s., Miocene to Recent. Cosmopolitan. Recent from the intertidal zone to 200 meters (109 fathoms), occasionally deeper. Subfamily Cardiinae, Late Triassic to Recent (Keen).

Description. — Shell ventricose, close or gaping posteriorly; umbones prominent, subcentral; radiately ribbed; margins crenulated; pallial line more or less sinuated.

Animal with the mantle-margins plaited; siphons clothed with tentacular filaments, anal orifice with a tubular valve; branchial fringed; foot long, cylindrical, sickle-shaped, heeled. (Tryon, G. W., Jr., Structural and Systematic Conchology, Vol. 3, p. 192, 1884.)

Remarks. — This genus, construed in a broad sense, is represented by about 200 species in all oceans. Some species are quite tolerant of brackish water, where the shell becomes smaller and thinner (823). Most of the species occur in shallow to moderate depths, but some of them occur down to depths of 183 meters (100 fathoms) or more.

When submerged, the species of *Cardium* lie covered with sand or sandy mud with only the edges of their shells or only their siphons reaching the water. However, they can move about by means of a strong muscular foot and have been reported to be able to leap several meters at a bound.

Sculpture of the shells is predominately radial although the valves of certain groups are nearly smooth or may have partial concentric ornamentation.

About a dozen and a half species have been described occurring in Tertiary strata in western North America and over a dozen are recorded living in marine waters between the Bering Sea and San Diego, California. About two dozen species and subspecies have been reported as living in tropical and subtropical west American waters.

Only three species, one referable to *Cardium* (*Dallocardia*), one to *Clinocardium*, and one to *Nemocardium*, are known with certainty to occur in the San Diego Formation.

SUBGENUS DALLOCARDIA STEWART

Dallocardia Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, pp. 37, 264, August 9, 1930.

Type species (by original designation). — "type species, *Cardium quadragenarium* Conrad" [= *Cardium quadragenarium* Conrad, Jour. Acad. Nat. Sci. Philadel-

phia, Vol. 7, Pt. 2, p. 230, pl. 17, fig. 5, 1837. "Inhabits near Sta. Barbara; rare."]

Range. — Late Oligocene (San Ramon Formation) to Recent. Recent from the intertidal zone to 137 meters (75 fathoms).

Description. — Differs from *Trachycardium* in the broader (longer) outline and in that the elongated nodes on the central ribs are placed diagonally on the posterior (and on some specimens also, to a lesser degree, on the anterior) sides.

Remarks. — *Trachycardium* Morch (824) differs from *Dallocardia* in that the shell is narrower in comparison to the height, the hinge is relatively coarser and especially in that the scales on the central ribs loop over the entire top of the ribs.

Stewart mentioned that *Dallocardia* and *Trachycardium* are not known to occur earlier than Neogene time. More recently Eames (825) questioned whether or not certain species in the Eocene strata of Pakistan might be referable to *Trachycardium*. Gardner (826) gave the range as Cretaceous to Recent, and Stephenson (827) referred a species from the Cenomanian, Cretaceous, of Texas, to Morch's unit. Finlay and Marwick (828) indicated that in New Zealand, *Trachycardium* is restricted to the Waitotaran Stage, early Pliocene.

Cardium (*Dallocardia*) *quadragenarium* Conrad
Plate 46, Figures 18, 20, 23

[*Cardium*]. *quadragenarium* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 230, pl. 17, fig. 5, 1837. — Weymouth, State Calif. Fish Game Comm., Fish Bull. No. 4, p. 28, pl. 5, fig. 1, 1924. "off shore from Santa Barbara southward."

Laevicardium (*Trachycardium*) *quadragenarium* Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 306, pl. 19, fig. 15, 1931. Various localities, early Miocene to Recent.

Trachycardium quadragenarium Conrad, Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 55, fig. 21, 1953. "Monterey Bay, California, to Cape San Lucas, Baja California," Recent. — Abbott, American Seashells (D. Van Nostrand Co., Inc.), p. 398, pl. 31, fig. A, 1954. "Santa Barbara to Lower California."

Type specimen. — Location unknown to the present authors.

Type locality. — "Inhabits near Sta. Barbara; rare."

Range. — Late Miocene to Recent. Recent from Monterey Bay, California (A. G. Smith and Gordon, 1948), to Todos Santos Bay, Lower California, from the intertidal zone to 137 meters (75 fathoms). In sandy mud with the edges of the valves projecting above the surface, in sloughs and sheltered waters of the open coast.

Occurrence in San Diego Fm. — C.A.S. 1402. L.A.M. 305, 305A.

Original description. — Shell cordate, subequilateral, ventricose, thick; ribs forty to forty-two, prominent, subangular, flattened at the sides with a series of small tubercles, which, on the anterior side, are largest, and placed in the middle of the ribs, but elsewhere on the posterior angular margin of the ribs; umbo broad,

prominent; beaks not oblique; tubercles elevated on the posterior slope; colour pale yellow, with fulvous spots and zones; posterior margin direct, deeply serrate. Height, three inches. (Conrad.)

Remarks. — Two specimens of this species are present in the Academy's collection from Balboa Park. A left valve, the better preserved of the two, is 51 mm high and 49.8 mm long. Although the preservation is imperfect, the shape, number of ribs (41 visible) and the spiny sculpture all correspond well with Recent specimens of *Cardium quadragenarium* of the same size. The umbonal portion of two valves, the large one about 50 mm high, and some other fragments, were collected at Loc. 305 (LAM) near the Mexican boundary. These valves also are similar to Recent specimens. A large Recent specimen from San Pedro, California, in the Hemphill collection in the California Academy of Sciences, is 124 mm long and 112 mm wide.

A fossil from Pliocene beds in Elsmere Canyon was described by Arnold as "*Cardium quadragenarium* Conrad var. *fernandoensis*." (829). It was said to differ from the typical species as follows: "This variety is more oblique, has narrower umbones, is relatively less in diameter, and has fewer and less prominently spinose ribs than the typical form." We have examined a cast of Arnold's type specimen. It possesses 36 ribs and agrees with Arnold's description of this form.

The species described as *Trachycardium sagaseri* (830) by Adegoke, from the Etchegoin Formation, is said to possess about 28 radial ribs.

The early Miocene species described as *Cardium* (*Trachycardium*) *vaquerosensis* Arnold (831) was said to differ from the form *fernandoensis* as follows: "It differs from *C. quadragenarium* Conrad, var. *fernandoensis* Arnold, from the lower Pliocene, by being much larger, more convex, having more prominent umbones, and having fewer, wider, deeper, steeper-sided interspaces." The type specimen has 34 radial ribs. As mentioned by Arnold, *C. vaquerosensis* is almost certainly the precursor of *C. quadragenarium*.

The species described as *Cardium* (*Trachycardium*) *gorokuense* Nomura (832) was compared by its author with *C. quadragenarium*. The Japanese fossil is a very small shell 3.7 mm in length and in general features resembles small specimens of Conrad's species. However, the ornamentation of the ribs appears to be different as it is said to bear closely set concentrically arranged scales, those on the posterior area somewhat spinose.

[*Cardium* (*Mexicardia*) *procerum* Sowerby]

Cardium procerum Sowerby, Proc. Zool. Soc., London for 1833, p. 83, September 8, 1833. — Reeve, Conch. Icon., Vol. 2, *Cardium*, sp. 51, pl. 10, fig. 51, 1844. Original locality cited. — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11, 1878. Later Tertiary of San Diego. Also Recent. — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 232, 1888. "Pl. — San Diego well." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1091, 1900. "From the Pliocene of the well in the City Park at San Diego, California."

Type specimen. — Syntypes in British Museum (Natural History).

Type locality. — "Hab. in América Centrali. (Real Llejos)." "Found in coarse sand in from four to six fathoms water."

Range. — Pliocene to Recent, Costa Rica, and Ecuador; late Pleistocene to Recent in Lower California; late Pleistocene in southern California. Recent from Lagoon Head, Lower California. (Lat. 28° 15' N., Long. 114° 07' W.), and the Gulf of California, to Bahía de la Independencia (Lat. 14° 15' S.), Peru (Olsson).

Occurrence in the San Diego Formation. — San Diego well (Cooper; Dall).

Remarks. — This species was not cited by Dall in his original list (1874) of the species found in the San Diego well. The first record of *Cardium procerum* in beds which might be presumed to be of Pliocene age at San Diego is that of Dall in 1878 in which he referred to its occurrence in "later Tertiary deposits." Cooper, 1888, cited it as occurring in the Pliocene strata of the San Diego well as did Dall in 1900. We do not know what specimens formed the basis of these records nor have we seen any specimens from beds of Pliocene age in that region.

Most authors consider the range of *Cardium procerum* to be from the southern portion of the outer coast of Lower California, and the Gulf of California, to Peru. Keen (1958, p. 116) recognized a northern form, said to be characterized by its triangular ribs (often with fine nodes along the crest) separated by linear interspaces, under the name of *Trachycardium* (*Mexicardia*) *panamense* Sowerby. The generally more southern form said to be characterized by its smooth, rounded ribs separated by rather wide, flat interspaces, was referred to *Trachycardium* (*Mexicardia*) *procerum* Sowerby. However, many authors consider these forms to be referable to a single species (see Olsson, 1961, p. 247).

GENUS *CLINOCARDIUM* KEEN

Clinocardium Keen, Trans. San Diego Soc. Nat. Hist., Vol. 8, No. 17, p. 119, March 12, 1936. — Habe, Gen. Jap. Shells, Pelecypoda No. 2, p. 150, 1951. "Type species: *Cardium nuttallii* Conrad, 1837."

Type species (by original designation). — "Genotype: *Cardium nuttallii* Conrad, 1837."

Range. — Late Oligocene or early Miocene (Japan), middle Miocene (western North America), to Recent. Recent from southern California to Japan, one species ranging through Arctic waters to the north Atlantic. Recent from the intertidal zone to 119 meters (65 fathoms). Occasionally reported deeper.

Original description. — Shell medium to large, trigonal, oblique, usually ventricose; beaks recurved, prosogyrate; position of the umbones varying with age but usually at two-thirds the distance between posterior and anterior ends of the shell; dorsal margin very broadly arched, sloping downward at an angle of about 25°, ventral and anterior margins broadly rounded; epidermis closely adherent, brownish; sculpture of 28 to 55 rounded radial ribs and concentric growth lines which may cross the ribs as conspicuous loops, never as spines; lunule when present circumscribed, never impressed; escutcheon inconspicuous; ligament in dorsal view long, narrow, and oval. Interior porcellaneous, ventral and anterior margins crenulate;

hinge arched; cardinals in each valve slightly nearer anterior margins crenulate; hinge arched; cardinals in each valve slightly nearer anterior than posterior laterals; anterior, also recurved; ligament not elevated on a short, shelly platform; beaks originating at a point slightly anterior to the anterior cardinals; muscle scars large; pallial line simple. Specimens range in length up to about 120 mm. (Keen.)

Remarks. — This genus includes thirteen species and subspecies from the late Cenozoic of western North America and about fifteen species from Japan and Sakhalin Island. One species is here recorded from the San Diego Formation for the first time. This is essentially a northern group of cockles. The type species has been recorded from beds of Pleistocene age as far south as San Quintín, Lower California, Mexico. Beal (833) mentioned "*Cardium* aff. *C. meekianum* Gabb" from much farther south, from beds of late Miocene age near Bahía de Magdalena.

Clinocardium differs from *Cerastoderma* Poli in Mörch (834), from the eastern Atlantic, in the strongly prosogyrate beaks, more numerous ribs, long, low ligament and arched hinge line. The prosogyrate beaks, coarse ribbing as well as the longer and lower ligament are features separating *Clinocardium* from *Laevicardium* Swainson (835).

The west American species of *Clinocardium* were discussed by Keen (836) and those of Japan by Hirayama (837).

Clinocardium nuttallii Conrad

Plate 46, Figure 21

Cochlea corbis Martyn (of west American authors), Univ.

Conch., Vol. 2, fig. 80, 1788 [Martyn's work was ruled unacceptable for nomenclature by the Internatl. Comm. Zool. Nomencl., Opinion 456, March 15, 1957.] — Chenu, Bibl. Conchyl., Première Sér., Vol. 2, p. 25, pl. 28, fig. 2, 1845. "Pulo-Condore."

C[ardium]. nuttallii Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 229, pl. 17, fig. 3, 1837.

Cardium corbis Martyn, Weymouth, Calif. State Fish Game Comm., Fish Bull. No. 4, p. 28, pl. 5, fig. 2, 1920. Gulf of Georgia, British Columbia, to San Diego, California, Recent. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 142, pl. 34, figs. 1a, 1b, 1924 (under subgenus *Cerastoderma*). Various localities cited.

Laevicardium (Cerastoderma) corbis Martyn, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 307, pl. 19, figs. 14, 17, 1931. Various localities; late Miocene to Recent.

Clinocardium nuttallii Conrad, Fitch, State Calif. Dept. Fish Game, Mar. Fish Branch, Fish Bull. No. 90, p. 57 fig. 23, 1953. Bering Sea to San Diego, California. Recent. — Addicott, U. S. G. S., Prof. Paper 523-C, p. C-4, pl. 3, fig. 1, 1966. Half a mile east-northeast of Año Nuevo, San Mateo Co., California. Pleistocene.

Type specimen. — One pair, No. 54036, Academy of Natural Sciences of Philadelphia (A. M. Keen, Veliger, Vol. 8, No. 3, p. 169, 1966).

Type locality. — "Inhabits muddy salt marshes, a few

miles from the estuary of the Columbia River."

Range. — "aff." Middle Miocene (838); late Miocene (C. E. Weaver); Pliocene to Recent. Recent from Kamtschatka to San Diego, California, from low tide to 55 meters (30 fathoms). Reported from Miocene to Recent in Japan.

Occurrence in San Diego Fm. — L.A.M. 107, 305, A-1323.

Original description. — Shell ovate-triangular, ventricose, thick; ribs thirty-four, regularly rounded, with prominent arched striae; umbo narrowed; summit very prominent; posterior slope much depressed; posterior margin straight, oblique, simply undulate; ligament margin declining; basal margin regularly arcuate; colour white; epidermis yellowish brown; lateral teeth thick and prominent; margin profoundly serrate. Height, three and a half inches. (Conrad.)

Remarks. — One specimen from Loc. 107 (LAM) partly decorticated, is 70.5 mm long and 84 mm high (beaks lacking) and has about 34 to 35 radial ribs. The shape and shell characters are those of *Clinocardium nuttallii* Conrad. This identification was confirmed by Dr. A. M. Keen who has made a special study of the Cardiidae. Two other casts and one incomplete specimen with portions of the shell, referable to this species, were collected at the same locality.

Two casts of valves in the collection of the Los Angeles County Museum were collected in Fossil Canyon near Chula Vista, the large one is approximately 80 mm long and 86 mm high. The shape and such traces of shell as remain agree with *C. nuttallii*. A right valve from Loc. 305 (LAM), about 43 mm long, the ribs nearly eroded, appears to be referable to this species.

Fraser (839) discussed the ecology of *C. nuttallii*. He found that most of the specimens were about four years old but that it may attain an age of seven years. He also pointed out that in the early stages of growth the length is greater than the height but after the first winter the height exceeds the length and this difference increases with age. This ratio of length to height may vary because a huge specimen from Atka Island, Alaska, mentioned by Keen (840) was 145 mm long, 138 mm high and the convexity 102 mm.

Mitchell (841) made a study of the microscopic structure of the shell and ligament and Taylor (842) discussed the effect of temperature on the growth of this species.

Clinocardium nuttallii differs from the well known Pliocene species, *C. meekianum* Gabb (843), in the less oblique outline, less abrupt posterior truncation and in the more numerous, narrower radial ribs (about 34 rather than about 28) which continue on over the posterior truncation.

A subspecies, *Clinocardium meekianum myrae* (844), from the Etchegoin Formation, with 28 to 30 ribs, was described recently by Adegoke.

This is the first record of *Clinocardium nuttallii* in the San Diego Formation, but it has been recorded from beds of similar age along the Pacific coast from California to Alaska. It has been reported from beds of Pleistocene age as far south as San Quintín, Lower California.

Slodkewitsch (845) reported this species from beds of late Tertiary age in Kamchatka and on Sakhalin Island and it also has been reported ranging from Miocene to

Recent in Japan (846).

Clinocardium nomurai Hayasaka (847) bears a general resemblance to *C. nuttallii* but it has only about 20 radial ribs and a smaller apical angle.

Clinocardium shinjiense Yokoyama (848) described from strata of late Tertiary age in Japan, with about the same number of ribs, has been confused with *C. nuttallii* but the sharp angular ribs are quite different and more closely resemble those of *C. ciliatum* Fabricius.

Fraser mentioned that *C. nuttallii* prefers a somewhat uniform sandy bottom or, if gravelly, confined to patches where the gravel is fairly uniform in size.

GENUS NEMOCARDIUM MEEK

Nemocardium Meek, Rept. U. S. Geol. Surv. Terr., Vol. 9, p. 167, 1876. *Cardium semiasperum* Deshayes cited. — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 273, 1931. Type (monotypy): *Cardium semi-asperum* Deshayes. — Tremlett, Proc. Malacol. Soc. London, Vol. 28, Pts. 4 & 5, p. 115, 1950 "Type-species. — *Cardium semiasperum* Deshayes." — Keen, Bull. Amer. Paleo., Vol. 35, No. 153, p. 9, 1954. Type as designated by Sacco.

Type species (by monotypy.) Also designated by Sacco, Moll. Terr. Terz. Piemonte e Liguria, Pt. 27, p. 56, 1899). — "tipo *N. semiasperum* (Desh.)" [*Cardium semiasperum* Deshayes, Anim. s. Vert. Bassin Paris, Vol. 1, p. 573, pl. 55, figs. 1, 2, 1860. "Localités: Aizy, Vregny, Laon." "Gisement: Sables inférieurs." France, Eocene. — Tremlett, Proc. Malacol. Soc. London, Vol. 28, Pts. 4 & 5, p. 121, pl. 16, figs. 9a, 9b, 1950. Hampshire Basin. London Clay, Eocene.]

Range. — Late Cretaceous to Recent. Recent from 18 to 200 meters (10 to 109 fathoms).

Original description. — Shell closely resembling the typical forms of *Protocardia*, but thinner, with two-thirds to three-fourths of surface in front of the stronger posterior, usually echinate, radiating costae, occupied by fine, crowded, radiating striae, and the free margins crenate within all around; cardinal and lateral teeth generally rather slender; pallial line faintly sinuous, irregularly serrated, or nearly simple behind. (Meek, 1876.)

The cardinal teeth in the hinge of this genus are very unequal in size.

Remarks. — *Nemocardium* is represented by a number of species throughout its geologic range, the greatest number of which occur in strata of Eocene age as indicated by Keen (849) in a discussion of this genus. In Europe *Nemocardium* s. s. is reported to range from Cretaceous to Miocene. In England it ranges from Cretaceous to Oligocene (Healdon beds (see Tremlett)). According to Finlay and Marwick (850), large forms of *Nemocardium* appeared in New Zealand first in the Kaiatan Stage, early Oligocene, and made their last appearance in the Awamoan Stage, middle Miocene. Later, Keen (1950, p. 25) reported the occurrence of one species of this genus in the Eocene of Australasia. In western North America *Nemocardium* s. s. ranges from late Cretaceous to middle Oligocene. The last representative in this region, so far as known, is *Cardium weaveri* Anderson and Martin (851) described from the Oligocene of Oregon. Recently,

Hickman (852) described *Nemocardium* (*Nemocardium*) *formosum* from strata in western Oregon assigned Oligocene age. Five Cenozoic species from the North American-northeast Asia region were referred by Keen [1954, p. 316 (10)] to *Nemocardium* s. s. In Japan this genus ranges from late Cretaceous to Recent, being represented in Oriental waters at the present time by *Cardium bechei* A. Adams and Reeve (853).

Stewart (854) gave a discussion of the genus *Protocardia* Beyrich, the type of which is *Cardium hillanum* Sowerby, and he pointed out the differences between that genus and *Nemocardium*. The posterior portion of the valves of the genus *Protocardia* is sculptured with radial ribs and the remainder of the valves is sculptured with concentric ribs.

Four rather similar subgenera of *Nemocardium* are separated in the following key which is adapted from Keen, 1954.

Key to Subgenera of *Nemocardium*

- A. Posterior ribs decidedly wider and heavier than the others, usually with spines or crests *Nemocardium* s. s.
- B. Posterior ribs not decidedly wider than the others.
 - a. Outline ovate-trigonal; hinge relatively short *Arctopratalum*
 - aa. Outline ovate-trigonal; hinge relatively long and arched
 - b. Concentric lamellae on posterior area only *Keenaea*
 - bb. Concentric lamellae present over entire valve *Pratalum*

SUBGENUS KEENAEA HABE

Keenaea Habe, Gen. Jap. Shells. Pelecypoda, No. 2, p. 152, September, 1951. — Keen, Bull. Amer. Paleo., Vol. 35, No. 153, p. 317 (11), 1954. Original designation of type cited.

Type species (by original designation). — "Type species: *Cardium samarangae* Makiyama." [= *Nemocardium samarangae* Makiyama, Mem. Coll. Sci., Kyoto Imper. Univ., Ser. B, Vol. 10, No. 2, art. 6, p. 143, 1934. A new name for *Cardium modestum* A. Adams and Reeve, Zool. Voy. Samarang, Moll., Pt. 3, p. 77, pl. 22, fig. 6, 1848 (issued 1850). "Hah. Eastern Seas." (Not *Cardium modestum* Philippi, 1849; not *Cardium modestum* Conrad, 1855). Also illustrated by Habe, 1951, fig. 326 (p. 147).]

Range. — Late Oligocene to Recent. Japan to Lower California. Recent from 18 to 476 meters (10 to 260 fathoms).

Description. — Smaller than *Nemocardium* s. s., with secondary concentric lamellae on posterior ribs; the latter not sharply differentiated. Differs from *N.*

(*Pratulium*) by the presence of the concentric lamellae on ribs and a tendency toward fine beading on ribs of the central part of the disk. (Keen, 1954.)

Remarks. — Several Cenozoic species of the Cardiidae in the north Pacific region have at times been placed in various genera or subgenera such as *Protocardia* Beyrich, *Nemocardium* Meek, and *Pratulium* Iredale. Establishment of *Keenaea* as a subgenus for these species appears justified because of differences in the sculpture and hinges of these forms in comparison with the type species of other supraspecific units of the Cardiidae. Five Cenozoic species in the north and northeastern Pacific regions have been assigned (one tentatively) by Keen to the present subgenus.

Nemocardium (Keenaea) centifilosum Carpenter
Plate 46, Figures 4, 5, 10, 15

Cardium (?*modestum*, var.) *centifilosum* Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 611, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 97, 1872. — Carpenter, Proc. Calif. Acad. Nat. Sci., Vol. 3, p. 209, February, 1866. "Monterey, 20 fms. alive; Santa Barbara I, Catalina Island, 40 fms. Cooper."

Cardium var. *centifilosum* Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 642, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 128, 1872.

Cardium centifilosum Carpenter, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 297, 1874. "Well at San Diego." "Pliocene." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. San Diego well. — Cooper, Calif. State Min. Bur., Seventh Ann. Rept. Calif. State Mineral. p. 232, 1888. "Pl. — San Diego well." — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, August, 1889. Dall's record (1874) cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited from San Diego well. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) cited. Referred to *Nemocardium centifilosum* Carpenter.

Protocardia centifilosa Carpenter, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 142, 1903. "San Diego well (Dall)." "Pliocene." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 146, pl. 34, figs. 2a, 2b, 2c, 2d, 1924. Recent. Also cited from "San Diego." "Pliocene." — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 84, 1929. "San Diego Pliocene."

Cardium (Protocardia) centifilosum Carpenter, Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 267, pl. 20, figs. 2a, 2b, 2c, 2d, 1918. "Vicinity of the Farallon Islands in 40 to 46 fathoms."

Nemocardium (Keenaea) centifilosum Carpenter, K. V. W. Palmer, Geol. Soc. America, Mem. 76, pl. 91, pl. 10, figs. 7-11, 1958. (Holotype illustrated.)

Type specimen. — No. 15262, United States National Museum.

Type locality. — "Cat. Is., 30 — 40 fm." Carpenter, (1864, p. 611.) [Catalina Island, California. See K. V. W. Palmer, 1958, p. 92.]

Range. — Late Miocene (856) to Recent. Recent

from the Farallon Islands, California, to Point Abreojos, Lower California, Mexico, in 18 to 137 meters (10 to 75 fathoms).

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 1404, 12078, 28893. L.A.M. 107, 305A. S.D. 75, 294.

Original description. — "Probably = *modestum*, Ad. & Rve.; but rounder, ribs sharper and more distant."

Supplementary description. — C. T. parva, tenuissimâ, inflatâ, subquadratum rotundatâ; umbonis angustis, tumidioribus; marginibus, dorsalibus subalatis, antico et ventrali aequaliter rotundatis, postico vix truncato, totâ superficie, (nisi umbonibus et dorsum versus utroque latere laevigis,) tenue lirâtâ; liris circ. centum, quoad magnitudinem extantibus, angustis; interstitiis sub-equalibus, subquadratis, interdum punctato-decussatis; parte posticâ à lineâ definita, liris minus conspicuis, laminis concentricis extantibus, crebrioribus eleganter exasperata; intus, dent. card. validioribus, lat. subdistantibus; cic. adduct. ovalibus, haud impressis.

Long. 0.51, lat. 0.48, alt. 0.34. (Carpenter, 1866.)

Remarks. — The radial ribs on the posterior third of the shell of this species separated from the anterior series by a slight carina, are crossed by raised concentric lamellae.

A considerable number of specimens of *Nemocardium centifilosum* in various stages of preservation, are present in the collections from the San Diego Formation. These vary in size, many of those from Loc. 1404 (CAS), corner of India and Upas streets, are about 16 mm high; one of the largest ones is 18.8 mm high. A single left valve in the Hemphill collection from the San Diego well is approximately 16.4 mm long and 16.1 mm high. The largest specimen from Loc. 107 (LAM), end of Arroyo Drive, is a cast 19.8 mm long and 19 mm high. An impression of a right valve collected by Charles Sternberg on Reynard Way off State Street, is 22 mm long. One of the largest Recent specimens of *N. centifilosum* in the collections of the California Academy of Sciences from Cortez Bank off southern California, in 73 to 110 meters (40 to 60 fathoms), is 16.8 mm long and 16 mm high, convexity (both valves together), 11 mm. The fossil specimens agree in all observable characters with those of the Recent species.

A cast of both valves of a specimen from Loc. 107 (LAM), has the general shape of *Nemocardium* but it is much larger than any specimens of *N. centifilosum* which we have observed. It is 33.8 mm long, 33 mm high, the convexity (both valves together), approximately 27.3 mm. The shell material is lacking and no opinion is here ventured concerning the species represented by this cast.

A form described as *Cardium richardsoni* by Whiteaves (857) is now generally considered to be only a northern variety of *Nemocardium centifilosum*, ranging from Forrester Island, Alaska, to San Francisco, California. Dall (858) stated concerning this form, "The northern specimens forming the variety are a little stronger and coarser than those from California, with which they seem to be united by intermediate gradations, though the extremes have apparently good distinctions." However, as mentioned by Willett (859), and by Woodring, Bramlette, and Kew (860), the only difference between the northern and southern forms is in size. We have examined specimens collected by George Willett at Forrester Island,

Alaska, the largest of which is 21.6 mm long, 19.6 mm high, convexity (both valves together), 15.1 mm. Woodring, Bramlette, and Kew, reported large shells from Alaska which are 26.2 mm long and mentioned that the largest one from off Cortez Bank in the United States National Museum, is 19.6 mm long. A fossil valve which they illustrated from beds of Pleistocene age from San Pedro, California, is 24.9 mm long and 22.8 mm high and thus comparable in size to the northern form *N. centifilosum richardsoni*.

SUPERFAMILY VENERACEA RAFINESQUE (861)
FAMILY VENERIDAE RAFINESQUE (862)

Shell equivalve, porcelaneous, beaks prosogyrous, smooth or variously sculptured (predominantly concentric), lunule and escutcheon usually well defined, resilium external, margins crenulated or smooth; pallial sinus varying in different genera, often deeply sinuated; hinge with teeth radially arranged, one or more of the cardinals often bifid or grooved, right middle and left posterior ones usually thicker than right and left anterior teeth, a left anterior lateral may be well developed or lacking, posterior laterals usually small or lacking. Often burrowing just beneath surface of sea bottom. Jurassic to Recent.

Remarks. — This family, which has reached its greatest development and diversification at the present

time, contains many genera for which scores of names (see Frizzell, 1930) have been proposed.

Several authors have given special attention to this family among which are Dall (863), Jukes-Browne (864), Marwick (865), Palmer (866), Frizzell (867), Casey (868), and Keen (869). References to earlier works on this family can be found in those papers. A study of the Veneracean group led Casey to conclude (p. 158), "the author is convinced that the genera at present grouped in the family Veneridae (the superfamily Veneracea of Frizzell, 1936) are a polyphyletic assemblage of forms derived from various cyprinid and noncyprinid sources." However, he believed it best to leave undisturbed the systematic homogeneity of this well known family until evidence of a phylogenetic classification had been presented.

Recent tropical and subtropical west American species of the Veneridae were discussed by Hertlein and Strong (870), by Keen (871), and by Olsson (872).

Ansell (873) discussed the functional morphology of the British species of Veneracea.

GENUS *DOSINIA* SCOPOLI

Dosinia Scopoli, *Introductio ad historiam naturalem*, p. 399, 1777. Reference to: "*Cricompholos* Klein. Chama Dosin. Adans." — Hertlein and Strong, Bull.

Key To Genera Of Veneridae (874)

A. Left valve with an anterior lateral tooth or denticle.

- a. Shell orbicular, large, polished *Dosinia*
- aa. Shell trigonal or elongated.
 - b. Shell trigonal, beaks subcentral *Tivela*
 - bb. Shell longer than high; beaks anterior to midline.
 - c. Inner ventral margin obliquely grooved; not exceeding 35 mm in length *Transennella*
 - cc. Inner ventral margin not grooved
 - d. Exterior of valves with coarse concentric sculpture . . . *Saxidomus*
 - dd. Exterior of valves smooth or with fine concentric sculpture
 - e. Pedal retractor impression deeply excavated; shell larger rather thick *Megapitaria*
 - ee. Pedal retractor impression not deeply excavated; shell rather thin *Pitar*

B. Left valve lacking an anterior lateral tooth or denticle

- a. Exterior of valves smooth or with fine concentric sculpture
 - b. Shell obliquely elliptical, medium-sized to large; pallial sinus narrow *Compsomyax*
 - bb. Shell trigonal, not exceeding 8 mm in length; pallial sinus wide *Psephidia*
- aa. Exterior of valves with concentric and radial (always on beaks) sculpture
 - c. Escutcheon present on one or both valves
 - d. Left posterior cardinal elongated; middle cardinal thick; hinge plate triangular; pallial sinus short *Chione*
 - dd. Left posterior cardinal short; middle cardinal not thickened, bifid; hinge plate narrow and long; pallial sinus long *Protothaca*
 - cc. Escutcheon lacking *Irusella*

Amer. Mus. Nat. Hist., Vol. 107, Art. 2, p. 188, 1956.

Type (by monotypy): Chama Dosin Adanson.

Dosinidia Dall., Proc. U. S. Nat. Mus., Vol. 26, No. 1312, p. 437, December 29, 1902. "Type, *Venus concentrica* Born." [Rer. Nat. Mus. Caesaris Vindobonensis, Pars 1, Testacea, p. 58, 1778. (No locality cited. Ref. to "List Hist. Conch. 1, 3, f. 99, 102, 104."; "Petiv. Gaz. t. 16, f. 1, t. 93, f. 15, 18."); Test. Mus. Caesar. Vindobonensis, p. 71, pl. 5, 1780. "Habitat ad insulam Maurittii & Jamaicam, Lister."]

Type of genus (by monotypy): Chama Dosin Adanson, Hist. Nat. du Sénégal, p. 225, pl. 16, fig. 5, 1757. "On la voit assez abondamment sur la côte de Portugal." See Fischer-Piette et al., Jour. de Conchyl., Vol. 85, No. 4, p. 308, pl. 14, fig. 4, 1942 [A *Dosinia* (*Dosinia*) *concentrica*]. Also illustrated by Palmer, Palaeontogr. Americana, Vol. 1, No. 5, p. 278, pl. 49, figs. 2, 5, 10; pl. 51, fig. 4, 1927-1929. Pleistocene and Recent.

Range. — Eocene to Recent in New Zealand (Marwick); Oligocene (876) to Recent in western North America. Recent mostly in shallow tropical and subtropical waters to a depth of 120 meters (66 fathoms).

Description. — Shell orbicular, rather thick, valves moderately inflated, posterior dorsal margin usually very gently rounded and lending a flattened appearance; lunule well defined, escutcheon, if present, narrow, lacking in *Dosinia* s.s.; sculpture of fine, incised concentric grooves; hinge of left valve with 3 cardinals, ligament rather long, more or less sunken; pallial sinus usually ascending, pointed at the end; margins of valves smooth.

Remarks. — A discussion concerning the identification of the type species of this genus has been given by Fischer-Piette et al. and reviewed by Hertlein and Strong. It appears that Adanson's species "Chama Dosin" is identical with *Venus concentrica* Born. The subgenus *Dosinidia* Dall is thus a synonym of *Dosinia* s. s.

The tropical and subtropical genus *Dosinia* is represented in Neogene strata of western North America by several species. It ranged north to western Washington during middle Miocene time, but only north to Santa Clara Co. (877), California, in the Pliocene, and to Newport Bay, California, in late Pleistocene time.

One species, or perhaps two, and a subspecies described in the present paper, occur in strata of Pliocene age in southern California but only one occurs in beds of Pleistocene age in that region. Three species occur in the tropical and subtropical waters between Scammon's Lagoon, Lower California, to Punta Peñasco, Mexico, and south to Ecuador and two of them to Paita, Peru. Records of the occurrence of *Dosinia ponderosa* living in the waters of San Diego Bay are believed to have been based upon Pleistocene fossils.

SUBGENUS *DOSINIA* S. S.

Dosinia ponderosa diegoana n. subsp.

Plate 47, Figures 2, 3, 6, 8, 10; Plate 49, Figure 8; Plate 51, Figure 14

Dosinia ponderosa (Gray) variety *jacalitosana* Arnold, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, pp. 353, 912, pl. 15, figs. 2a, 2b, 1931. "*Dosinia* beds of Balboa Park, San Diego (Hertlein and Grant)."

Not *Dosinia jacalitosana* Arnold, 1910.

Dosinia ponderosa (Gray), var., Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 222, pp. 89, 104, pl. 16, fig. 6; pl. 19, fig. 1; pl. 20, fig. 7, 1950. Careaga Sandstone, Santa Maria district. Also cited from "U. S. Geol. Survey localities 2459, 2662 (Balboa Park)", San Diego.

Dosinia ponderosa Gray, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 38, pl. 17, figs. a, b, 1968. "near the Mexican-United States boundary and one-half a mile from the ocean". Pliocene.

Not *Arthemis ponderosa* Gray, 1838.

Description. — Shell large, elongately orbicular, equivalve, moderately inflated, beaks situated decidedly anterior; lunule large and impressed; anterior margin and ventral margin broadly rounded, posterior dorsal margin gently rounded and merging into the posterior margin which is very broadly rounded and lending a subtruncated appearance; surface sculptured with concentric incremental lines; hinge similar to that of *Dosinia ponderosa* but the ventral margin of the hinge plate is more arcuate and the anterior lateral tooth of the left valve is separated by a greater distance from the anterior cardinal. Length, 121 mm, height, 130 mm, convexity (both valves together, gaping 13 mm along ventral margin), 63 mm.

Type specimen. — Holotype (and paratypes) in the California Academy of Sciences, Department of Geology, Type Collection; paratypes in the San Diego Society of Natural History and in the Los Angeles County Museum, Invertebrate Paleontology Collection.

Type locality. — *Dosinia* beds in Balboa Park, on point between Cabrillo Canyon and a gulch, about 100 meters south of the west end of Laurel Street Bridge over Cabrillo Canyon, San Diego.

Range. — Middle Pliocene, San Diego Formation at San Diego, and in the Careaga Formation in the Santa Maria district, California.

Occurrence in San Diego Fm. — C.A.S. 1181, 1401, 1402, 1415, 36384. L.A.M. P.87, 104, 107, 127, 180, 305, 305A, 319. S.D. 29, 80, 408, 417, 05252. U.C. A-8333. U.C.L.A. 312, 1386, 2359.

Remarks. — *Dosinia ponderosa diegoana*, new subspecies, differs from *Dosinia ponderosa* in that the outline is more elongated (dorsal to ventral), the beaks are more anteriorly situated, the lunule is shallower, the posterior dorsal margin is less projecting, lending a subtruncated appearance to the posterior portion of the shell, the ventral margin of the hinge plate is more arcuate, and the anterior lateral of the left valve is separated from the anterior cardinal by a correspondingly greater space.

This subspecies appears to be intermediate in shell characters between *Dosinia ponderosa* (878) and *Dosinia jacalitosana* Arnold (879). Some specimens from Balboa Park are nearly as elongate in outline as *D. jacalitosana* but on most specimens the posterior dorsal margin is more acutely rounded than that of *D. jacalitosana*. The hinge of the type of the latter has not been described, but Nomland (880) illustrated the hinge of a right valve attributed to Arnold's species. The results of a study of a series of specimens from the San Diego Formation lead us to describe this form as a subspecies of *D. ponderosa* rather than to identify it with *D. jacalitosana* or with either of the forms of late Miocene age placed in the synonymy of that species by Grant and Gale.

Woodring pointed out that the form which he illustrated from the Careaga Sandstone in the Santa Maria district is identical with the *Dosinia* occurring in Balboa Park in San Diego.

The elongated form, very anteriorly placed beaks and subtruncated posterior end are features easily separating this new subspecies from *Dosinia arnoldi* Clark and *D. merriami* Clark from beds of late Miocene age in California.

GENUS TIVELA LINK

Tivela Link, Beschreib. Naturalien-Sammlung Rostock, Pt. 2, p. 152, 1807. Species cited: "*Tivela vulgaris*." "*Venus corbicula*. L. G. p. 3278" in synon.: and "*Tivela tripla*." "*V. tripla*. L. G. p. 3276" in synon. — Nickles Moll. Test. Marins Cote Occid. d'Afrique, Man. Ouest-Africain, Vol. 2, p. 199, 1950.

Type species (designated by Kobelt, Illustr. Conchylienbuch, Bd. 2, Lief. 10-11, p. 334, 1881). — "Typus ist *Cytherea tripla* Linné (Taf. 97 Fig. 12) von der Westafrikanischen Küste." [Also illustrated by Römer, Monogr. Molluskengattung *Venus*, Linné (Cassel), Bd. 1, p. 20, pl. 7 figs. 2, 2a-c, 1861. West Africa. — Nickles, 1950, p. 199, fig. 378. For a discussion of this species see Dodge, H., Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 122-123, 1952.]

Range. — Eocene to Recent (*Tivela* s. s., Miocene to Recent). Recent from the intertidal zone to 73 meters (40 fathoms).

Description. — Shell trigonal, smooth, medium size; external ligament short in the typical species; hinge with three cardinal teeth in each valve and an anterior lateral in the left valve; inner margins smooth; pallial sinus deep, rounded at the end.

Remarks. — The type species is a highly trigonal shell about 20-35 mm in altitude. The anterior and posterior areas are flattened and a lunular area is delimited by a fine thread. The external ligamental area is comparatively small. The pallial sinus extends anteriorly to about two-thirds the distance from the posterior margin.

The general characters of the type species differ so much from those of the huge coarse shells of west American species usually referred to *Tivela* that it seems desirable to place the California species in the subgenus *Pachydesma* Conrad.

Dodge considered Herrmannsen's designation of the type of *Tivela* to be equivocal. There may be an element of doubt concerning the validity of that designation but there is no question concerning the validity of the designation of the same species by Kobelt.

SUBGENUS PACHYDESMA CONRAD

Trigonella Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 253, 1837.

Sole species, *Cytherea crassatelloides* Conrad. Not *Trigonella* Da Costa, 1778, nor *Trigonella* Hehl, 1842. *Pachydesma* Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 31, March 1854. New name for *Trigonella* Conrad, 1837, not of Da Costa, 1778, nor of Hehl,

1842. "This name being superseded, I propose to substitute that of *Pachydesma*". — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 266, 1961. Type species, *Donax stultorum* Mawe.

Type species (by monotypy). — *Cytherea crassatelloides* Conrad.

Range. — Eocene to Recent. Recent from the intertidal zone to about 24 meters (13 fathoms).

Description. — Shell large, thick, trigonally elongate, porcelaneous, beaks prominent, lunule not defined; distinct setting off of the left cardinal from the nymph; three cardinal teeth in each valve (sometimes with accessories), a large anterior lateral tooth in the left valve and two lateral lamellae in the right valve.

Remarks. — The recorded occurrence of species of *Pachydesma* in California in beds as early as those of Eocene age suggests the possibility that this subgenus originated in west American waters.

Tivela (Pachydesma) stultorum Mawe
Plate 50, Figures 4, 5, 6

Donax stultorum Mawe, Linn. Syst. Conch., pp. 37, 40, pl. 9, fig. 7, 1823. [No description.]

Cytherea crassatelloides Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 253, pl. 19, fig. 17, 1837 (under subgenus *Trigonella*).

Cytherea (Tivela) crassatelloides Conrad, Stearns, Proc. U. S. Nat. Mus., Vol. 21, No. 1149, pp. 371-378, pls. 23-25, 1898. Santa Cruz, California, to Ballenas Bay, Lower California.

Tivela stultorum Mawe, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 340, pl. 19, fig. 8, 1931. (Reproduction of Mawe's original figure.) [Not figs. 3a, 3b? = *Tivela scarificata* Berry.] Pliocene to Recent.

Type specimen. — Location unknown to the present authors. Type specimen of *Cytherea crassatelloides* Conrad, one pair No. 53900, Academy of Natural Sciences of Philadelphia (A. M. Keen, Veliger, Vol. 8, No. 3, p. 169, 1966).

Type locality. — "Indian Seas." [Original locality believed to be erroneous. The type locality of *Cytherea (Trigonella) crassatelloides* Conrad, generally considered to be identical with *Donax stultorum* Mawe, is, "Inhabits the coast of California about a foot deep in the sand — abundant round Sta. Diego as well as near Sta. Barbara."]

Range. — Middle Pliocene to Recent. Recent from Stinson Beach, Marin Co., California (881), to Magdalena Bay, Lower California, Mexico, from the intertidal zone to a depth of 24 meters (80 feet), living at a depth of about 150 mm (6 inches), on a clean sandy beach where there is a heavy surf.

Occurrence in San Diego Fm. — L.A.M. 305, 305C, 319, A-1323. U.C.L.A. 294, 305, 312, 1383.

Original description of *Cytherea crassatelloides*. — Shell equilateral, triangular, thick; convex-depressed; lunule undefined; posterior extremity truncated; ligament short, very broad and elevated; apex very prominent; beaks not oblique; colour whitish, frequently rayed with brown; cardinal teeth very thick and prominent; anterior tooth elongated, thick; sinus of pallial impression angular. Length, seven inches. (Conrad.)

Remarks. — Several single valves of this species are present in the collections of the University of California at Los Angeles. The largest specimen, a right valve, is 78.8 mm long, 62.2 mm high, the convexity, 15.4 mm. This is small in comparison to a Recent specimen collected by Mr. John Strohbeen which is 162 mm long, 131 mm high, the convexity (both valves together), 77.5 mm. Fitch (882) mentioned a specimen which was 187 mm long.

Two single valves and some fragments of this species are present in the collections of the Los Angeles County Museum. A fragment of a left valve from Loc. 305 (LAM), from near the Mexican boundary, is 10 mm thick.

The present record of this species in the San Diego Formation is the first unless the equivocal record of Orcutt (883) refers to specimens of Pliocene age. He cited it from Tertiary beds at Pacific Beach. This species has been recorded from other localities in California in strata of Pliocene age in the San Benito quad., in the Santa Maria district, in Los Angeles, and in the Merced Formation in northern California.

There have been differences of opinion as to the correct name for this species. Certainly Conrad's *Cytherea crassatelloides* from southern California is referable to this species. However, most authors in modern times have accepted *Donax stultorum* Mawe as representing this species. The locality "Indian Seas" given by Mawe for this species is generally believed to be an error. The only modern record we have noticed of the identification of *Tivela stultorum* in oriental waters is that in a list of shells from Hongkong, mentioned by Campbell (884) who attributed the identification to H. A. Pilsbry. That list contains such American species as *Pecten circularis* Sowerby, *Olivella biplicata* Sowerby, *Busycon perversa* Linnaeus, and *Olivella sayana* Ravenel, and cannot be considered as an authoritative locality record for Mawe's species.

Woodring (885) considered the assignment of *Donax stultorum* to west American waters a very doubtful procedure and preferred retention of the name *Tivela crassatelloides* for the west American species.

Cytherea virginea A. Adams and Reeve was described with the locality "Eastern Seas." Tomlin examined the type specimen and concluded that it is identical with the California species which he cited as *Tivela stultorum*. This conclusion was affirmed by the French authors Fischer and Fischer-Piette. Evidence supporting the opinions of those authors is that several species recorded from oriental waters by A. Adams and Reeve are now known to be west American species. Among these are "*Artemis*" *dunkeri* Philippi, "*Mastra*" *thracioides* A. Adams and Reeve, "*Lucina*" *sericata* Reeve, and *Conus borneensis* A. Adams and Reeve (now believed to be identical with *Conus arcuatus* Broderip).

The present authors feel that the use of *Tivela stultorum* for a west American species is justified unless definite proof is forthcoming that the name is applicable to an oriental species.

Tivela scarificata Berry (886) which occurs in beds of Pleistocene age in southern California differs from *T. stultorum* in the more elongate shape and in the presence of scar-like markings on the interior.

An interesting form generally considered to be referable to *Tivela stultorum* has been discussed by Fitch (887). He pointed out that individuals of this species

living in sand along with numerous specimens of *Donax gouldii* develop an elongate shape and often reveal the presence of an area of irregular zone of growth just anterior to the posterior umbonal margin. This irregular growth is believed to be the result of injury to the corresponding portion of the mantle caused by pinching by the valves of *Donax gouldii*. One of the fossils in the present collection shows a similar zone of irregular growth.

Two excellent papers dealing with *Tivela stultorum* in present day waters are by Weymouth (888) and Fitch (889). Young shells are said to possess a hyssus which later becomes obsolete.

[GENUS PITAR RÖMER]

Pitar Römer, Kritische Untersuchung, der Arten des Molluskengeschlechts *Venus* bei Linné und Gmelin mit Berücksichtigung der später beschriebenen Arten (Cas- sel), p. 15, 1857. Sole species, "*C. tumens* Gmel." — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 232, 1930. Monotype species *Venus tumens* Gmelin.

Caryatis Römer, Malakozool. Blätter, Bd. 9, pp. 58, 60, March, 1862. Species cited: *Cytherea tumens* Gmelin, *Cytherea striata* Sowerby, and others. — Stoliczka, Mem. Geol. Surv. India, Palaeo. Indica, Ser. 6, Vol. 3 pp. XVIII, 151, 1871. "*Venus tumens*, Gmelin, is the type of this very well marked form of *Cytherea*."

Not *Caryatis* Hübner, 1816. Lepidoptera.

Pitaria Römer (emended), Dall, Proc. U. S. Nat. Mus., Vol. 26, No. 1312, p. 353, December 29, 1902. "Type *Venus tumens* Gmelin."

Type species (by monotypy): "*C. tumens* Gmel. (le *Pitar* Adans.)" [= *Cytherea tumens* Gmelin, Linn. Syst. Nat., ed. 13, p. 3292, 1791. "Habitat ad Africa littus occidentale." Ref. to Adanson, Hist. Nat. du Sénégal, pl. 16, fig. 7, 1857. Locality, p. 226, "Elle est également répandue sur toute la côte sablonneuse depuis le cap Verd jusqu'au fleuve Gambie." See also P. -H. Fischer et al., Jour. de Conchyl., Vol. 85, No. 4, p. 316, pl. 14, fig. 6, 1942. Also illustrated by Römer, Monogr. Molluskengattung *Venus*, Linné, Bd. 1, p. 81, pl. 22, figs. 1, 1a, 1b, 1c, 1869. "Mare Senegalense et Guineense; (Bathurst in ins. Stae Mariae)." Also illustrated by Tegland, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 10, p. 277, pl. 21, figs. 1-3, 1929 (as *Pitaria* (*Pitaria*) *tumens*).

Range. — Eocene to Recent. Recent chiefly in tropical and subtropical waters, a few species in warm waters, from the intertidal zone to 540 meters (295 fathoms).

Description. — Shell medium-sized, trigonal-ovate, strongly inflated; lunule wide, limited by a slightly depressed groove; escutcheon indistinct; sculpture consisting of incrementals; hinge of right valve consisting of 2 indistinct anterior lateral lamellae flanking a deep socket, and 3 cardinals, the anterior (3a) and middle (1) ones almost perpendicular to hinge-margin, the middle one heavy, the posterior one (3b) bifid; hinge of left valve consisting of a heavy anterior lateral and 3 cardinals, the anterior one (2a) resembling the right anterior cardinal (3a), the middle one (2b) very heavy and obscurely bifid, the posterior one (4b) slender and partly joined to the nymph; pallial sinus deep, its apex acutely angular.

(Woodring, W. P., Carnegie Inst. Washington, Publ. 366, p. 152, 1925.)

Remarks. — This genus is represented in the Cenozoic of western North America by a number of species. About 18 or 20 species and subspecies have been recorded as occurring in the Cenozoic of California and additional species occur in the Tertiary strata of Oregon, Washington, Alaska, and elsewhere.

Some authors have used Dall's emendation of the genus name, *Pitaria*, but as mentioned by Iredale, 1924, and Stewart, 1930, there appears to be no justification for this. *Pitar*, according to authorities on the classical languages is correct as it stands. In the Sanscrit language *Pitar* means father, according to Baugh (890). It is interesting to note that the word "*Pitar*" also was used by natives in the western Pacific (891).

Katherinella Tegland, (892), described as a subgenus of *Pitar*, with the type *Pitaria arnoldi* Weaver, differs from typical *Pitar* in that the anterior lateral of the left valve is small and extends from near the lower margin of the hinge plate upward nearly to the junction of the cardinals. The shell is thin and the valves are only moderately inflated. This subgenus is known to occur only in beds assigned to late Oligocene age, and to middle Miocene age, in Oregon, Washington, and Alaska.

Pitar is represented in the late Pliocene and Quaternary in southern California by two species. Fourteen species and subspecies were cited by Hertlein and Strong as occurring in tropical and subtropical west American waters and Olsson has added three more from northern South America.

[*Pitar newcombiana* Gabb]

[*irce*]. [*Lioconcha*]. *newcombiana* Gabb, Proc. Calif. Acad. Nat. Sci., Vol. 3, p. 189, January, 1865.

[?] "*Callista* sp. indet." Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 296, 1874. Well at San Diego. — Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 85, August, 1889. Dall's record cited. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919.

Callista newcombiana Gabb, Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 231, 1888. "Pl. — San Diego well." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 144, 1903. "Pliocene. — San Diego well (Cooper)."

Pitaria newcombiana Gabb, I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 151, pl. 57, fig. 2, 1924. "Pliocene at San Diego Well, California."

Pitar newcombiana Gabb, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 345, 1931. "Pliocene; San Diego well, Balboa Park, San Diego (Cooper)."

Type specimen. — Location of type specimen unknown to the present authors.

Type locality. — "Hab. two valves, Catalina Island, 120 fms. Dr. Cooper."

Range. — ? Late Pliocene, southern California, to Recent. Recent from Monterey, California, to Punta Peñasco in the Gulf of California and south to Port Guatulo, and Clarion Island, Mexico.

Occurrence in the San Diego Formation. — Based upon records of Dall and Cooper.

Remarks. — Dall in 1874 mentioned a fossil bivalve

occurring in the San Diego well as "*Callista* sp. indet. Smooth, inflated, thin; much like *Callista newcombiana*, erroneously described as *Lioconcha* by Gabb" (893). Cooper in 1888 cited "*Callista newcombiana* Gabb" from the San Diego well, and most subsequent records in the literature appear to be based upon his record. We have not seen specimens of this species from the San Diego Formation, and it has not been reported from strata of Pliocene age in southern California. It may perhaps occur in beds of that age, but for the present we are unable to validate its occurrence at San Diego.

Records of the occurrence of this species in beds of late Miocene age cited by Clark, 1914, and Weaver, 1950, may be based upon some other species.

GENUS *MEGAPITARIA* GRANT AND GALE

Megapitaria Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 346, November 3, 1931. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 272, 1961. Type, by original designation.

Type species (by original designation). — "Type, *Cytherea aurantiaca* Sowerby" [Gen. Rec. and Foss. Shells, Vol. 2, Pt. 33, pl. 196, fig. 3, 1831. (No locality cited.) — Reeve, Conch. Icon., Vol. 14, *Dione*, species 12, pl. 3, fig. 12, 1863 (as *Dione aurantia*). "Hab. Acapulco, South America." — Olsson, 1961, p. 273, pl. 46, figs. 1, 1a, 1c (as *Macrocallista (Megapitaria) aurantiaca*). Lower California to northern Peru].

Range. — Pliocene to Recent. Recent from the intertidal zone to 161 meters (88 fathoms).

Description. — Shells usually large or of moderate size, thick, ovate-subtrigonal, ventricose, smooth, sculptured only with fine lines of growth. Differing from *Pitar* s. s. in the larger, thicker shell and in the deep pedal retractor impression.

Remarks. — Shells of typical *Megapitaria* were referred to *Macrocallista* Meek (894) in the earlier literature. They resemble that genus in general shell characters but the valves are more ovate or circular in shape and are less depressed. They resemble the genus *Pitar* Römer which was described much earlier than *Macrocallista* but they are much larger and thicker. Grant and Gale gave an adequate discussion of *Megapitaria* which they compared with other genera. This genus is based upon a west American species and until the relations of the various supra-specific groups of the Veneridae are more clearly delimited, it seems best to apply *Megapitaria* to shells similar to the type species.

Megapitaria squalida Sowerby

Plate 50, Figures 1-3

Cytherea squalida Sowerby, Proc. Zool. Soc. London for 1835, p. 23, issued April 16, 1835. — Sowerby, Thes. Conch., Vol. 2, *Cytherea*, p. 629, pl. 131, figs. 87, 88, 89, 1851. "California." [Not the record "from the Philippine Islands."]

Dione squalida Sowerby, Reeve, Conch. Icon., Vol. 14, *Dione*, species 10, pl. 3 fig. 10, 1863. "Hab. California." [Not the record "Philippine Islands."]

Pitar (Megapitaria) squalidus Sowerby, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 347, 1931.

Various localities cited, Pliocene to Recent.

Megapitaria squalida Sowerby, Hertlein and Strong, Zoologica, Vol. 33, Pt. 4, p. 168, 1948. "Range: Scammon Lagoon, Lower California, to the Gulf of California and south to Mancora, Peru." — Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 134, fig. 303, 1958. [Same range as in preceding reference.]

Macrocallista (Megapitaria) squalida Sowerby, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 273, pl. 46, figs. 2, 2 a-c, 1961. Lower California to northern Peru.

Type specimen. — British Museum (Natural History).

Type locality. — "Hab. ad Sanctam Elenam."

"Found in sandy mud at a depth of six fathoms."

Range. — Middle Pliocene to Recent. Recent from Cedros Island, Lower California, Mexico, to the Gulf of California, and south to Mancora, Peru; on sandy mud flats to a depth of 161 meters (88 fathoms).

Occurrence in San Diego Fm. — L.A.M. 302.

Original description. — Cyth. testâ ovato-subcordatâ, crassiusculâ, laevi, pallidè fuscâ, nonnunquam maculis irregularibus saturatoribus; epiderme fuscâ; latere postico longiore, prope partem hentralem subacuminato: long. 2.7, lat. 1.3, Alt. 2. poll. (Sowerby.)

Remarks. — Three valves of this species, the largest, a right valve about 61 mm long, are present in the collections of the Los Angeles County Museum from Loc. 302 (LAM). These fossils agree in all details with Recent specimens of this species. A fragment from Loc. 122, Pacific Beach, may have come from beds of Pleistocene age.

This is the first record of *Megapitaria squalida* from the San Diego Formation. It has been reported with question from Strata of Pliocene age and definitely from beds of Pleistocene age in southern California. It also has been recorded from Pliocene to Recent in Lower California and in Ecuador. Recent specimens 116 mm long have been reported from the Gulf of California.

Megapitaria squalida differs from the similar *M. aurantiaca* Sowerby which lives in the same region, in that the shell is more produced both anteriorly and posteriorly and in that it possesses a shiny purplish-brown or spotted or striped periostracum rather than dull orange brown.

GENUS COMPSOMYAX STEWART

Compsomyax Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 224, August 9, 1930. — Grand and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 333, 1931. Type as indicated by Stewart.

Type species (by original designation). — "Type species, *Saxidomus gibbosus* Gabb (= *V. subdiaphana* (Carpenter))." [Geol. Surv. Calif., Palaeo., Vol. 2, p. 58 pl. 16, figs. 18, 18a, 18b, 1869. "Common in the Pliocene of Eagle Prairie, Humboldt County." Also illustrated by Stewart, 1930, pl. 14, fig. 6 (lectotype).]

Range. — Early (895) or middle Miocene (Temblor) to Recent, western North America. Japan, Miocene. Recent from 2 to 548 meters (1 to 300 fathoms).

Original description. — "This species differs from typical *Venerella* in having a strongly bifid posterior right cardinal."

Remarks. — The type species of *Compsomyax* was originally described under the genus *Saxidomus*, later placed in *Marcia* H. and A. Adams, in *Venerella* Cossmann, and finally *Compsomyax* was proposed for it by Stewart. This in turn has been cited as a subgenus of *Venerella* and *Katherinella* and in some cases has received the rank of genus.

The hinge of *Compsomyax* lacks an anterior lateral tooth in the left valve which separates it from *Pitar* Römer and *Katherinella* Tegland (896). Both *Compsomyax* and *Katherinella* occur in strata of middle Miocene age in Washington. It has been suggested by some authors that *Compsomyax* originated from *Katherinella* by the disappearance of the anterior lateral tooth on the left valve. The hinge bears a resemblance to that of *Clementia* Gray but the posterior cardinal tooth of *Compsomyax* is much more deeply bifid. Furthermore the shells referable to Gray's genus are undulated and possess a deeper pallial sinus. *Marcia* H. and A. Adams, type designated by Kobelt (897), *Venus pinguis* Chemnitz from East Indian seas, belongs to a different group from *Compsomyax*.

Venerella Cossmann (898) has been discussed by Stewart (1930, pp. 223-224), who placed *Compsomyax* as a subgenus of it. We have examined a specimen of the type species of *Venerella* from Havelon near Hermonville, France, of middle Eocene age, sent to us by Mr. J. L. Staid. Stewart remarked on the small size of European species of this group, and this observation is borne out by the present specimen which is 14.2 mm long and 11.3 mm high, convexity (both valves together), approximately 7.5 mm. A comparison of the hinge of this specimen with that of *Compsomyax subdiaphana* reveals that the posterior cardinal of the right valve is not bifid and the middle cardinal is more broadly trigonal in shape in comparison to those of the corresponding ones on Carpenter's species.

A consideration of these facts leads us to assign *Compsomyax* generic status.

Compsomyax subdiaphana Carpenter

Plate 47, Figures 4, 7; Plate 57, Figure 15

Clementia subdiaphana Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 602, 607, 640, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 88, 93, 126, 1872. — Carpenter, Proc. Acad. Nat. Sci. Philadelphia, Vol. 17, p. 56, 1865. [Full description.] "In sinu Pugetiano. . ." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 28, 1878. San Diego well. — Cooper, Calif. State Min. Bur., 7th Ann. Rept. State Mineral, Vol. 7, p. 235, 1888. "Pl. — San Diego well." — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 86, 1889. Dall's record (1878) cited. — Dall, Proc. U. S. Nat. Mus., Vol. 14, No. 849, p. 185, pl. 7, figs. 5, 6, 1891. Various localities, from Port Etches, Alaska, to near entrance of San Francisco Bay, California, in 14-16 fathoms, Recent. — Orcutt, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 60, 1919. Dall's record (1878) cited.

Callista subdiaphana Carpenter, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 144, pl. 13, fig. 4 ("Pliocene, Deadman Island."), 1903. "Pliocene. — San Diego well (Cooper)." Also Pleistocene and Recent.

Marcia subdiaphana Carpenter, Dall, Trans. Wagner Free

Inst. Sci., Vol. 3, Pt. 6, p. 1321, October, 1903. Refers to Cooper's record from "Pliocene of San Diego, California." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 155, pl. 33, fig. 1; pl. 38, fig. 1, 1924. Range, Sannakh Islands, Alaska, to Santa Barbara Islands and San Pedro, California, Recent. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 79, p. 84, 1929. "San Diego Pliocene." Also in Elsmere, Pico, and Holser canyons, Pliocene.

Clementia (Compsomyax) subdiaphana Carpenter, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 334, pl. 17, figs. 10a, 10b, ?15, 1931. "San Diego well (Cooper)." Also earlier records.

Compsomyax subdiaphana Carpenter, K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 93, pl. 10, figs. 1-6, 1958. (Type specimen illustrated.)

Type specimen. — No. 4541, United States National Museum.

Type locality. — "Recent. Puget Sound, Washington (type)." (Palmer, 1958.)

Range. — Late Miocene; Pliocene to Recent. Recent from Sannakh Islands, Alaska, to Cedros Island, Lower California, Mexico, in 2 to 548 meters (1 to 300 fathoms).

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 1404, 28889. L.A.M. 104, 107, 305, 305A. S.D. 75, 294, 295, 302, 2359.

Original description. — "Intermediate between *Clementia* proper and the *prora* group of thin *Callistae*" (1864, p. 602). "Hinge normal, very thin, ashy" (1864, p. 640).

Supplementary description. — ?*C. t. ovali*, quoad genus valde transversâ, tumidâ, tenuissimâ; pallide cinerâ, epidermide pallide stramineâ; subdiaphanâ, sed subcalcareâ, haud porcellanâ; laevi, nisi striis incrementi; haud lunulatâ, umbonibus satis prominentibus: intus, valvâ dextrâ, dentibus anticis duobus acutis, contiguâ, elevatis, postico elongato, acuto, bifido, ligamento parallelo; valvâ sinistrâ dentibus anticis duobus, umbonem versus junctis, acutis, divergentibus, postico elongato, acuto, simplici; sinu palii, ut in *Dosinia*, angusto, angulato, per dimidium interstitii umbones versus porrecto. Long. .72, lat. .58, alt. .34. (Carpenter, 1865.)

Remarks. — The largest and best preserved specimen of this species in the collections at hand is one from Loc. 1404 (CAS), embankment at the corner of India and Upas streets in San Diego. It is 41.4 mm long, 36 mm high, the convexity (both valves together), 24.6 mm.

A number of specimens are in the collections of the Los Angeles County Museum, one of the largest is about 35 mm long. A left valve from Loc. 305 (LAM), although not perfectly preserved, retains much of the hinge which is identical with that of Recent *C. subdiaphana* of comparable size.

There is considerable variation in convexity and in the proportion of length to height in a series of Recent shells of this species. A large specimen in the collections of the California Academy of Sciences from Loc. 5084 (CAS), Port Ludlow, Puget Sound, Washington, is 68.8 mm long, 58 mm high, convexity (both valves together), 40.5 mm. A more elongate specimen from Loc. 19689 (CAS), San Juan Islands, Puget Sound, is 65 mm long, 48.6 mm high, convexity (both valves together), 36.4 mm. The shape and the general characters of the thin-shelled

fossils from the San Diego Formation are similar to those of Recent *C. subdiaphana* of comparable size.

Compsomyax subdiaphana is not certainly known to occur in beds earlier than of Pliocene age. Records of this species in beds of Miocene age in some cases are doubtful because some of these occurrences involve the species described as *Cytherea oregonensis* Conrad, a mid-Miocene species which Etherington (889) believed to be referable to the genus *Pitar*. Moore (900), who examined Conrad's type specimen of that species considered it to be a "*nomen dubium*." The species illustrated by Dall, 1909, under the name of *Marcia oregonensis* Conrad from strata of Pliocene age at Coos Bay, Oregon, is referable to *C. subdiaphana*. The species described by Conrad from Miocene beds at Astoria, Oregon, under the names of *Venus angustifrons* (901) and *Venus brevilineata* (902) (the latter considered by Etherington to be a variety of the former), are Miocene relatives of *C. subdiaphana*. Etherington believed these differed from the Recent species in shape, and "in the absence of the sunken area just anterior to the beak." A fossil cited as "*Marcia angustifrons* (Conrad)", the identification attributed to Durham and Kirk, was cited by Travis (903) as occurring in the Merced beds of Pliocene age in the southwestern portion of the Sebastopol quad. in north central California. Some specimens of *Compsomyax* from strata of Miocene age in Oregon and Washington are very similar to the Recent form. In general, the Recent shells appear to possess a wider ligamental area between the two valves noticeable when viewed from above.

Woodring (904) mentioned that two species, *Lutaria? traskei* and *Dosinia longula*, from the late Tertiary of California described by Conrad in 1856, may be closely comparable to *C. subdiaphana* but that the types of the two fossils "are so inadequate that the names may be considered nomina dubia." Grant and Gale (1931, pl. 22, fig. 1) published an illustration of the holotype of *Dosinia longula* which, unless deformed, does not closely resemble typical *C. subdiaphana*.

The species described as *Saxidomus gibbosus* by Gabb (905) from the Pliocene of Humboldt Co., Calif., was based on a large, globose form of Carpenter's species. Most authors do not consider it to be of taxonomic significance.

The form described as *Callista subdiaphana* var. *pedroana* by Arnold (1903, p. 144, pl. 13, fig. 2) from the Lower San Pedro beds at San Pedro, California, of Pleistocene age, is generally considered to be only a small valve of *Compsomyax subdiaphana*.

Clementia obliqua Jukes-Browne (906), described from "Porto Rico" (mistaken locality), is identical with Carpenter's species.

Species very similar to *Compsomyax subdiaphana* occur in the Miocene of Japan. The species described as *Meretrix iizukai* Yokoyama (907), as pointed out by Stewart, is remarkably similar in shell characters observable in the illustrations. More recently "*Clementia (Compsomyax) subdiaphana yazawaensis* Otuka" (908) and "*Clementia (Compsomyax) aff. subdiaphana* Carpenter" (909) have been cited by Otuka from the Miocene of Japan.

GENUS *SAXIDOMUS* CONRAD

Saxidomus Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 249, 1837. Sole species, *Saxidomus nuttalli* Conrad. — Dall, Proc. U. S. Nat. Mus., Vol. 26, No. 1312, p. 356, 1902. "Type, *S. nuttalli* Conrad." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1280, 1903. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 341, 1931.

Type species (by monotypy). — *Saxidomus nuttalli* Conrad.

Range. — Early Miocene to Recent. Recent from San Quintín, Lower California, Mexico, to Japan. ?Chile. Recent from the intertidal zone to 37 meters (20 fathoms).

Description. — Shell large, rude, chalky, ovate-quadrate, with low beaks, and concentric usually feeble sculpture; the ligament is strong and not depressed; there is no defined lunular area or escutcheon; internal margins smooth; pallial line with a deep, rounded sinus; hinge with three cardinals in each valve; the posterior right cardinal bifid; anterior laterals closely adjacent to the cardinals, one of the left ones often in line with the anterior cardinal. (Dall, 1902).

Remarks. — The exact relationship of *Saxidomus* to similar genera in the Veneridae is not certainly known. Romer (910) long ago discussed this genus and the species assigned to it. Grant and Gale ventured the opinion that the cardinal teeth may have been multiplied by division in a manner comparable to some of the paphias.

The earliest known species appear in the early Miocene of California. Species assigned to *Saxidomus* in beds of pre-Miocene age, such as "*Saxidomus* (?) *noblei*" Dickerson (911), from the early Eocene of California, are almost certainly referable to other genera. The type of that Eocene species is poorly preserved and the hinge is unknown.

We have examined a cast of the holotype of *Saxidomus popofianus* Dall (912) from beds of presumably medial Tertiary age on the Shumagin Islands. The species is based upon an internal cast about 51 mm long. The pallial sinus is short, V-shaped, rounded at the end, extending forward only about 19 mm from the posterior end. We can add nothing concerning the affinities of this form.

Saxidomus is represented in the late Tertiary of California by four or five species and in the Pleistocene by two. Two species and one subspecies now live in west American waters in the region between Alaska and northern Lower California. Two and perhaps three species have been reported from strata of Miocene age in Japan. One species now lives in Japanese waters.

This genus is generally considered to be limited in distribution, both fossil and Recent, to the north and northeast Pacific. The species described from Chile as *Venus opacus* Sowerby (913) has been referred to various genera by different authors. Römer, and later Carcelles and Williamson (914), assigned it to *Saxidomus*. More recently it was placed in *Eurhomalea* Cossmann (915) by Soot-Ryen (916).

Von Ihering (917) believed that *Saxidomus* originated along the west coast of North America and that it reached the southern portion of the west coast of South America during the Pleistocene. We have not studied specimens from Chile.

Key to Species And Subspecies of *Saxidomus*

- A. Anterior end broad and long (subspecies) *latus*
- B. Anterior end rather narrow and short *nuttalli*

Saxidomus nuttalli Conrad

Saxidomus [*nuttalli*] Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 249, pl. 19, fig. 12, 1837. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 174, 182, 1912. "San Diego — Purisima." — Weymouth, Calif. State Fish Game Comm., Fish Bull. No. 4, p. 35, pl. 7, figs. 1 and 2, 1920. "Bollinas Bay to San Diego," California. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 341, pl. 18, fig. 11, 1931. Late Miocene to Recent, California. — Fitch, State Calif. Dept. Fish Game, Fish Bull. No. 90, p. 64, fig. 30, 1935. "Humboldt Bay, California, to San Quintín Bay, Baja California," Recent. — Abbott, American Sea Shells (D. Van Nostrand Co., Inc.; New York), p. 417, pl. 31, fig. 1, 1954. "Humboldt Bay, California, to Lower California."

Type specimen. — Two syntypes No. 43.12.6.76 and 55.3.14.48, British Museum (Natural History) (A. M. Keen, Veliger, Vol. 8, No. 3, p. 169, 1966).

Type locality. — "Inhabits the coast of California and Sta. Diego, burrowing into soft clay-stone accompanying the Pholades, Cummingae, & c."

Range. — Middle Miocene (Temblor (918); Topanga) to Recent. Recent, Humboldt Bay, California, to San Quintín Bay, Lower California, Mexico. In bays and lagoons at depths of 12-18 inches in sandy mud or sand which is usually exposed at low tide. To a depth of 37 meters (20 fathoms).

Occurrence in San Diego Fm. — "San Diego-Purisima" (J. P. Smith). L.A.M. 305A, 318, 319, P.87: 58442. U.C.L.A. 312, 1386.

Original description. Shell suboval; disk rough, with concentric striae, elevated on the posterior slope; posterior extremity truncated; colour white, with brown spots and stripes about the umbo and ligament margin. Length, two inches. (Conrad.)

Remarks — Several specimens of this species are present in the collections of the Los Angeles County Museum from near the Mexican boundary. Three of these from Loc. 319 (LAM) retain both valves, the largest is 119 mm long, 89 mm high and the convexity (both valves, somewhat compressed together), 59 mm. Some of the valves are 4 mm thick. The anterior portion of a valve from Loc. 318 (LAM), is 101 mm long, 89 mm high, the convexity, approximately 29 mm. Three specimens of this species, also from near the Mexican boundary, are in the collections of the University of California at Los Angeles. The shell characters of all these specimens are similar to those of Recent *Saxidomus nuttalli*.

An imperfect cast from Sand Rock Canyon, San Diego, 64.2 mm long, in the collections of San Diego Society of Natural History is probably referable to *S. nuttalli*.

The generally more northern species *Saxidomus*

giganteus Deshayes (919) has a generally smaller, more rounded, much smoother shell.

Saxidomus vaquerosensis Arnold (920), described from beds of middle Miocene age, has a narrower outline and more regular and finer concentric sculpture, and, according to its author, is probably the precursor of *S. nuttalli*. "*Saxidomus cf. vaquerosensis* Arnold" was recorded by Hertlein and Jordan (921) from beds of middle Miocene age in Lower California.

Khomenko (922) cited a species under the name of *S. vaquerosensis* from the Matchgar series, which he considered to be of early Miocene age on the Schmidt Peninsula, Kamtschatka. Confirmation of this identification or of close relationship with the west American species is desirable.

A species from beds of Miocene age in Japan, cited by Nomura and Hatai under the name of "*Saxidomus Nuttalli* Conrad" was later named *Saxidomus nomurai* by Hatai and Nisiyama (923).

Saxidomus nuttalli reaches a length of about 171 mm (7 inches). Smith (924) discussed the ecology and growth of this species.

Gavala y Laborde (925) believed that resemblance existed between *Cochlea gilva* Martyn (926) from Poulo Condore Islands in the South China Sea, South Vietnam, and *Saxidomus nuttalli* Conrad illustrated by Sowerby (Thes. Conch., Vol. 2, pl. 164, fig. 10). However, an inspection of Martyn's illustration supports Solem's assignment of the East Indian species to a different genus and family (see *Trapezium sowerbyi* Hidalgo, Solem, Proc. Malacol. Soc. London, Vol. 31, Pt. 2, p. 70, pl. 5, figs. 1, 2, 1954).

Saxidomus nuttalli latus Stewart
Plate 50, Figures 8, 10

Saxidomus nuttalli latus Stewart, in Woodring, Stewart, and Richards, U. S. G. S., Prof. Paper 195, p. 94, pl. 8, fig. 15; pl. 16, fig. 8 (as *Saxidomus nuttalli latus*); pl. 33, fig. 6, 1940, issued June 7, 1941.

Saxidomus sp. aff. *S. nuttalli* Conrad, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 52, pl. 24, figs. a, b, 1968. "Pliocene in Balboa Park, San Diego."

Type specimen. — No. 495782, United States National Museum.

Type locality. — Loc. 87 (U. S. G. S.), "North Dome, sec. 9, T. 22 S., R. 18 E.; 1,520 feet north, 625 feet east; divide between Arroyo Pequeño and Arroyo Finito," Kettleman Hills, San Joaquin Co., California. San Joaquin Formation, late Pliocene.

Range. — Etchegoin, San Joaquin, and San Diego formations, middle Pliocene, California.

Occurrence in San Diego Fm. — C.A.S. 12051. S.D. 70.

Original description. — "...has a wider and longer anterior end than the living California *S. nuttalli*."

Remarks. — Two valves of this subspecies are present in the Henry Hemphill collection from the San Diego well. The larger valve, a right valve, 119 mm in length, is imperfect; lacks the ventral portion of the valve but the anterior dorsal margin is more flaring, broader, and the posterior dorsal margin is straighter than that of Recent *Saxidomus nuttalli* Conrad. Probably some variation exists in a series of specimens. Stewart mentioned that

"some specimens from the upper *Mya* zone have smaller adductor scars and a shallower pallial sinus than the Recent form, but the figured specimen from that horizon has a deep pallial sinus."

Another feature noticed on the larger valve at hand is the prominent and longer nymph plate and this no doubt is because of the straighter dorsal margin on the subspecies. This specimen agrees well with Stewart's illustrations (especially his plate 16, figure 3).

The enumerated differences characterizing the subspecies are more noticeable on larger than on smaller specimens. A left valve from the San Diego well, length 72 mm, height, approximately 51 mm, apparently has a straighter posterior dorsal margin than that on Recent specimens of comparable size.

GENUS *CHIONE* MEGERLE VON MÜHLFELD

Chione Megerle von Mühlfeld, Gesellschaft Naturf. Freunde zu Berlin, Jahrg. 5, p. 51, 1811. Species cited: "*Chione Dysera*" with references to "Linn. Syst. Nat. Gen 309. Sp. 4.a" and "Chemn. Conch. 6. t. 28. f. 287-290"; "*Chione Gallina*" with references to "Linn. Syst. Nat., Gen 309, Sp. 9, beta 114.a" and "Chemn. Conch. 6. t. 30, f. 308-310." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 318 1931. Type as indicated by Gray.

Type species (designated by Gray, Proc. Zool. Soc. London for 1847, p. 183). — "*Chione Dysera*" [Linnaeus]. [The figure cited by Linnaeus (Syst. Nat., p. 685, 1758) to represent typical *Venus dysera* was based on Argenville, Conch., pl. 24, fig. K, which may represent *Venus plicata* Gmelin (Linn. Syst. Nat., ed. 13, Tom. 1, Pars 6, p. 3276, 1791. "in mari indico". References to "Argenv. Conch. t. 21. f. k", "Valent. Abh. t. 15, f. 21.", "Chemn. Conch. 6. t. 28. f. 295-297"). The figures cited by Megerle von Mühlfeld as representing *Venus dysera* are those of Chemnitz (Syst. Conchyl.-Cab., Bd. 6, pl. 28, figs. 287-290, 1792) with the localities (p. 296) "westindischen Strände" and "Jamaica". These figures represent *Venus cancellata* Linnaeus (Syst. Nat., ed. 12, p. 1130, 1767. "Habitat in Oceano Africano." Reference to Gualtieri, Test., pl. 88, fig. D.), the species traditionally accepted as type of *Chione*. We follow this practice at least until a definite settlement of the selection of the type species is sanctioned by the Internatl. Comm. of Zool. Nomencl. Dodge (Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 89-92, 1952) has given a full discussion of the problem of the type species of *Chione*. *Venus cancellata* Linnaeus is well illustrated by K. V. W. Palmer (Palaeontogr. Americana, Vol. 1, No. 5, p. 359 (151), pl. 68 (37), figs. 1-6, 6a, 7, 8, 11, 15, 1927), with the range from Cape Hatteras, North Carolina, to Brazil, the Gulf of Mexico, and West Indies.)]

Range. — Late Oligocene or early Miocene to Recent. Recent in warm temperate and tropical waters, from the intertidal zone to 232 meters (127 fathoms).

Description. — Subtrigonal, thick, anteriorly rounded, posterior ventral margin somewhat pointed, beaks prosogyrous; lunule and escutcheon well defined; concentric lamellae well developed, and may or may not be crossed by radial sculpture; radial ribs usually present; ligament sunk below escutcheon; hinge of left valve with

2 or 3 cardinals, the posterior one usually bifid, right valve with 3 in addition to a posterior ridge, the anterior one small, the middle and the posterior ones large, usually slightly grooved; pallial sinus short; inner margins of the valves finely crenulated.

Remarks. — About 30 species and 7 subspecies of *Chione* have been described from the Cenozoic of western North America. Many of these species have been discussed and illustrated by Parker (1927). Some of the tropical species were separated later into different genera by Olsson (1961). Three species are known to occur in the San Diego Formation.

The earliest occurrence of *Chione* s. s. in southern California is in strata of middle Pliocene age. Species of this subgenus now live in tropical, subtropical and warm temperate American waters. Two species of this subgenus range north to Point Mugu, California (34° N.) but during Pleistocene time one of these ranged north to Tomales Bay (38° 10' N.). *Chione fluctifraga* Sowerby, the type of *Chionista* Keen, ranges north to Morro Bay, San Luis Obispo Co., at the present time.

Anomalocardia Schumacher has a hinge similar to that of *Chione* but the concentric sculpture is composed of prominent, thick, concentric rugae rather than lamellae. The concentric sculpture is predominant.

Iliochoione Olsson (1928) was recently proposed to include tropical west American species formerly placed in the genus *Anomalocardia*.

Key To Subgenera Of *Chione*

- A. Ligament anteriorly extending deeply into the valve and above the nymph; pallial sinus short but well developed and angular at the end *Securella*
- B. Ligament extending only slightly into the valve and onto the nymph; pallial sinus very short or almost lacking, somewhat rounded at the end *Chione* s. s.

SUBGENUS *CHIONE* S. S.

Key to Species of *Chione* s. s.

- A. Concentric lamellae evenly spaced; radial ribs coarse *undatella*
- B. Concentric lamellae very closely crowded; radial ribs fine *allisoni*

Chione (*Chione*) *allisoni* n. sp.

Plate 51, Figures 11-16

Description. — Shell of holotype (a left valve) of medium size, elongately trigonal, moderately thin, moderately convex; sculpture consisting of rather fine radial ribs which may be bifid or trifid, these are crossed by thin, low, concentric lamellae, moderately spaced on the early portion of the valve, but over most of the shell these are very closely spaced; lunule with fine sculpture similar to the remainder of the valve; escutcheon on left valve,

smooth, steeply sloping; hinge with a thin anterior cardinal which slopes forward, a fairly thick central tooth and a narrow posterior ridge which extends from beneath the beak almost to the dorsal margin of the hinge plate; pallial sinus very short, pointed; interior margin finely denticulated. Right valve (paratype) similar to the left except that the escutcheon is less well developed and on some valves less well defined; hinge with a short anterior tooth fused to the lunular margin, central and posterior teeth well developed. Dimensions of the holotype, length 32.6 mm, height 27.2 mm, convexity (one valve) 10.2 mm.

Holotype, a left valve, and paratypes, in the collection of the San Diego Society of Natural History. Paratypes, in the collection of the San Diego Society of Natural History. Paratypes also deposited in the Department of Geology, California Academy of Sciences, and in the Los Angeles County Museum.

Type locality. — Loc. 222 (San Diego State College), two miles south-southeast of Mt. Soledad and 200 yards north of Kate Sessions Elementary School; shell bed exposed at middle of south facing bank (about six feet above house level) at rear of lot on northeast corner of Edgeworth Road and Blackmore Court, community of Pacific Beach, city of San Diego, collected by Charles N. Howell, 1964.

Range. — Known only from the type locality and vicinity.

Occurrence in San Diego Fm. — S.D.S.C. 222, 223.

Remarks. — About 75 valves of this species have been available for study. The largest specimen, a right valve from Loc. 222 (SDSC) is 35.4 mm long and 31.8 mm high. A more rounded specimen from Loc. 223 (SDSC), is 31.4 mm long and 31.2 mm high. In general the shells are longer than high.

The shape and general appearance of the valves are somewhat similar to that of *Chione undatella* Sowerby. However, all specimens of this new species differ from *C. undatella* in the thinner shell, finer radial ribs, and fine, low, extremely closely spaced concentric lamellae. One specimen in the lot has rather coarse radial ribbing and in shape somewhat resembles that of *C. californiensis gealeyi* Parker (1929).

The generally fine radial ribbing and low, closely spaced, concentric lamellae, lend a general resemblance to *Chione* (*Nioche*) *asperima* Sowerby (1930), the type species of *Nioche* Hertlein and Strong. However, the general shape, lack of radial ribs along the posterior dorsal margin, the kind of sculpture on the early portion of the valves, as well as the short pallial sinus, all more closely resemble those features on *C. undatella* than on any other species. For this reason we assign the new species here described to *Chione* s. s. rather than to *Nioche* Hertlein and Strong.

This species is named for the late Dr. Edwin C. Allison, Department of Geology, San Diego State College in recognition of his contributions to the knowledge of the stratigraphy and paleontology of Lower California.

Chione (*Chione*) cf. *C. (C.) undatella* Sowerby

The following references, type specimen, type locality and description refer to typical *C. undatella*.

Venus undatella Sowerby, Proc. Zool. Soc. London, p. 22, April 6, 1835. — Sowerby, Thes. Conch. Vol. 2, p. 711, pl. 153, fig. 22, 1853. "Found on the shore at the island of Tres Marias, Gulf of California."

Venus neglecta Sowerby, Beechey's Voy., p. 151, pl. 41, fig. 8, 1839. "Inhabits sandy mud on the coast of Central America."

Venus simillima Sowerby, Thes. Conch., Vol. 2, p. 708, pl. 153, figs. 17, 18, 1853. "California." — Reeve, Conch. Icon., Vol. 14, *Venus*, species 44, pl. 13, fig. 44, 1863. "Hab. San Diego, California."

Chione undatella Sowerby, Hertlein and Strong, Zoologica, Vol. 33, pt. 4, p. 182, 1948. "Mugu Point, California, to Paita, Peru."

Chione (Chione) undatella Sowerby, Parker, Jour. Paleo., Vol. 23, No. 6, p. 581, pl. 89, fig. 1; pl. 90, figs. 12, 13, 1949. Recent, Cedros Island, Lower California, to Panama. Pleistocene, San Pedro, California. Late Pliocene and early Pleistocene of the Gulf of California and the Galápagos Islands.

Type specimen. — British Museum (Natural History).

Type locality. — "Hab. in Sinu Californiensi. (Island of Tres Marias.)" "Found on the shore."

Range. — Middle Pliocene to Recent. Recent, Mugu Point, California, to Panama and the Galapagos Islands; from the beach to 91 meters (50 fathoms), usually on sand or sandy mud bottom.

Occurrence in San Diego Fm. — L.A.M. 302, 305.

Original description. — Ven. testâ rotundato-ellipticâ, crassâ, albidâ, fusco maculatâ punctatâ et undatim pictâ, costellis radiantibus confertis, aliisque decussantibus undulatis sublamellosis; latere antico brevior, postico subdeclivi, marginibus depressis; margine ventrali rotundato, intus crenulato: Long. 1.6; lat. 1., alt. 1.5 poll. (Sowerby.)

Remarks: The specimens here provisionally referred to *Chione undatella* are fragments the largest of which, the umbonal portion of a right valve 22mm high, retain the hinge. These were embedded in matrix along with *Megapitaria squalida*, *Anadara trilineata*, and *Pecten healeyi*. The shell characters, especially the sharp, evenly and rather closely spaced concentric lamellae, are identical with Recent specimens of *C. undatella* from San Ignacio Lagoon, Lower California, and elsewhere.

The shell of this species is similar to that of *C. californiensis* Broderip (931) but the valves are generally slightly more inflated and ornamented with sharper, more numerous, more closely spaced concentric lamellae, about 4 to 6 per centimeter on the middle of a valve.

Study of a large series of specimens of the present species reveals so much variation that we are inclined to refer numerous named variants to *C. undatella* including *Venus neglecta* Sowerby, 1835; *Venus nuttalli* Conrad, 1837; *Venus entobapta* Jonas, 1845; *Cytherea sugillata* Jonas, 1845; *Venus perdix* Valenciennes, 1846; *V. simillima* Sowerby, 1853; *V. excavata* Carpenter, 1857; *V. bilineata* Reeve, 1863; *Chione undatella* var. *taberi* Parker 1949.

SUBGENUS SECURELLA PARKER

Securella Parker, Jour. Paleo., Vol. 23, No. 6, p. 587, November, 1949.

Type species (by original designation). — "Geno-

type. — *Venus securis* Shumard (Pl. 94, figs. 8, 12, 19; pl. 95; pl. 95, fig. 6)." [*Venus securis* Shumard, Trans. Acad. Sci. St. Louis, Vol. 1, No. 2, p. 122, 1858. "Collected by Dr. Evans in gray, fine-grained sandstone of the Miocene age, at the mouth of Coos Bay, Cape Blanco, and on the shores of the Columbia short distance above Astoria, Oregon Territory. At all of these localities it is quite common." — Dall, U.S. G. S., Prof. Paper No. 59, p. 120, pl. 11, fig. 8; pl. 13, figs. 2, 8, 9, 1909 (as *Chione securis*). Coos Bay, Oregon, late Miocene [Pliocene]. (A reprint of Shumard's original description on pp. 187-188). — Trumbull, Jour. Paleo., Vol. 32, No. 5, p. 903, pl. 117, figs. 1-3, September, 1958 (as *Chione (Securella) securis*. Lectotype and hypotype illustrated).

Range. — Late Oligocene to middle Pliocene, north-eastern Pacific, Alaska to California; Kamtschatka, and Japan.

Original description. — Ligament deeply sunken in shell, wedging out between hinge plates; right, middle and posterior cardinals slightly grooved; left middle cardinal deeply grooved so that posterior portion of tooth larger and higher than anterior; sculpture of evenly spaced thin concentric ridges arising from a layer of concentrically disposed shelly material; this layer underlain by distinct radial ribs not visible on the surface; this condition of exclusively concentric ribs usually modified by erosion of shell, so that the common worn and leached specimens exhibit ornamentation with varying degrees of prominence and numbers of radial and concentric ribs; lunule deeply impressed, it is never removed, but escutcheon is often obliterated at an early state by erosion. For hinge characters, see also *S. ensifera* (Dall) (pl. 89, fig. 4). (Parker.)

Remarks. — The smooth surface on uneroded shells, crossed only by concentric lamellae, is a shell character which serves to separate this subgenus from *Chione* s.s. and *Chionopsis* Olsson. The thin, erect, concentric lamellae of *Securella* are quite different from the thicker, curved lamellae of *Lirophora* Conrad. The deep ligamental grooves which wedge out under the posterior dorsal margins of the valves are quite different from the corresponding grooves of the other subgenera of *Chione* mentioned above. Thirteen species from the medial Tertiary of the western United States were referred to *Securella* by Parker.

Chione (Securella) kanakoffi n. sp.

Plate 49, Figures 1, 3, 4, 5, 6;

Plate 51, Figures 4, 5, 6, 7, 10

Description. — Shell large, thick, ovately trigonal in outline, evenly convex; beaks prosogyrous; anterior end rounded and merging into the broadly rounded ventral margin, posterior dorsal margin very gently rounded to the posterior end which is very broadly rounded into the ventral margin with only a faint trace of a posterior truncation; lunule broadly cordate, concave, bounded by an impressed line; escutcheon extends to the posterior end and is crossed by concentric lamellae; a narrow, very faintly depressed area extends parallel to and just anterior to the posterior dorsal margin; sculpture consists of thin concentric lamellae spaced about 5 or 6 mm apart over much of the valve but more closely spaced toward both ends and along the ventral margin, the areas between the lamellae are smooth but radial riblets are exposed where

the surface is eroded, these are fine on the umbo but coarser toward the ventral margin. Dimensions: length 129 mm; height 122 mm; convexity (both valves together) 76 mm.

Hinge of right valve (paratype) with three cardinals, the anterior one rather thin, the middle and posterior ones fairly thick and medially grooved; a nymph plate about equal in length to the posterior cardinal occurs above it; a ligamental groove extends deeply under the dorsal margin; the base of the hinge is decidedly convex (upward) from below the middle cardinal to the posterior margin; pallial sinus short, V-shaped and extends forward 44 mm from the posterior margin, and points toward about the lower portion of the anterior adductor muscle impression; adductor impressions large and deep; margin of valve nearly smooth, with faint indications of radial sculpture which is covered by a calcareous layer. Hinge of left valve (paratype) similar to that of the right valve, but with a thinner, faintly grooved posterior cardinal, a fairly thick and medially grooved central one and a fairly thick anterior cardinal.

On some specimens the ventral margin, where eroded, is denticulated where the underlying radial sculpture is exposed.

Type specimens. — Holotype, right valve, and paratypes, Invertebrate Paleontology Collection, Los Angeles County Museum.

Type locality. — Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U. S. G. S. topog. map, San Ysidro quad., rev. 1953); G. P. Kanakoff, collector. Paratype from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U. S. G. S. topog. map, San Ysidro quad., ed. 1943); G. P. Kanakoff, collector. Paratype from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM), at the same elevation; fossils in float slump and consolidated boulders and silt and sandstone, and silt in place; G. P. Kanakoff, collector.

Additional occurrences in the San Diego Fm. — C. A. S. 1181, 28885, 28892. L. A. M. 305A, 318, 319. S. D. 4. U. C. L. A. 294, 312, 2359. S. D. S. C. 32.

Range. — Known only from the type locality and vicinity of San Diego.

Remarks. — This species is well represented in the collections of the Los Angeles County Museum from near the Mexican boundary by two specimens with both valves together and by ten large single valves in various states of preservation and by many fragments, and by more than 100 small ones. The shell of one of the fragments is 9 mm thick. The amount of radial sculpture exposed on the exterior of the valves is in direct proportion to the amount of erosion of the surface. Three fragments of valves, the largest 90.5 mm long are present in the collections of the University of California at Los Angeles from the same area as well as one right valve in the collections of San Diego State College. Small specimens in the collections of the California Academy of Sciences probably also came from near the Mexican boundary and from other localities.

Chione kanakoffi n. sp. more closely resembles *Chione semiplicata* Nomland (1932), which was described from beds of late Miocene age, than any described species.

It differs from that species in the more expanded and rounded anterior end, the more evenly convex valves and less flattened area along the posterior dorsal margin and in the more widely spaced concentric lamellae.

Compared with *Chione margaritana* Anderson and Martin (1933), the shell of the new species is more orbicular in outline, the height is greater in proportion to the length and the umbos are broader.

Compared to *Chione panzana* Anderson and Martin (1934) the valves of the new species are more highly convex, the posterior end is more rounded, the lunule is broader and the concentric lamellae are much more widely spaced.

Parker (1935) placed *C. margaritana* in the synonymy of *C. panzana* but a comparison of the type specimens of these two species reveals that they apparently represent distinct species. Two other elongate species, *C. vickeryi* Wiedey (1936) and *C. schencki* Loel and Corey (1937), described from beds of Miocene age, were considered by Parker (1949, p. 584) to be founded upon deformed specimens which he placed in the synonymy of *C. semiplicata* Nomland. The two specimens are no doubt somewhat deformed but whether they are identical with *C. semiplicata* may be open to question.

A comparison of *C. kanakoffi*, new species, with *C. elsmereensis* English (1938) reveals that the shell of the new species is more rounded posteriorly, and the radial ribbing (exposed by erosion) is much finer.

Small specimens of this new species were cited by the senior author (1939) from the San Diego Formation under the name of *Chione fernandoensis* English. More than one hundred valves from Loc. 305A (LAM), 4 to 23 mm in length, of juvenile *Chione kanakoffi* n. sp. have been available for study. These have been compared with a cast of the specimen of *Chione fernandoensis* (1940) illustrated by English, later cited as the holotype by Parker, and also with a cast of the specimen illustrated and cited as a paratype by Parker. Keen and Bentson (1941) evidently considered these two specimens to be syntypes. We have also had available for comparison specimens of *C. fernandoensis* from Loc. 710 (CAS), Elsmere Canyon, Los Angeles Co., California.

None of the small specimens from the San Diego Formation are definitely referable to *C. fernandoensis* and we consider them to be juvenile forms of *C. kanakoffi* n. sp.

The general appearance of *C. kanakoffi* n. sp. is that of a plumper form, more rounded, more convex, the beaks more projecting and the posterior dorsal margin is not so straight and not so strongly angulated and the lunule is more depressed. The concentric lamellae on these juvenile forms are often greatly eroded but there are about 10 to 18 on specimens 10.8 to 18 mm long. Some of these valves were bored by gastropods.

Over fifty valves of a small species of *Chione*, 4 to 20 mm in length, from Loc. 291 (LAM), Pico Formation, Humphrey's quad., are identical with valves of the same size from the San Diego Formation.

Parker (1942) illustrated four specimens under the name of *Chione (Anomalocardia) fernandoensis*. His figures 14 and 16 of a specimen from Elsmere Canyon apparently represent *C. fernandoensis*. His figures 13 and 18, indicated as a paratype, represent a specimen with rather highly projecting umbos. This apparently represents a different species resembling in general outline species

such as *C. securis* Shumard. Parker's figures 7, 8, and 15 represent specimens of Pleistocene age and do not closely resemble typical *C. fernandoensis*.

Chione mariae d'Orbigny (943) now living in tropical west American waters, is more trigonal in outline and has fewer concentric lamellae than either juvenile *C. kanakoffi* n. sp., or *C. fernandoensis*.

GENUS PROTOTHACA DALL

Protothaca Dall, Proc. U. S. Nat. Mus., Vol. 26, No. 1312, p. 364, December 29, 1902. — Frizzell, Proc. Geol. Soc. Amer. for 1934, pp. 387-388, 1935. Type as indicated by Dall. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 304, 1961. Original designation of type species cited.

Type species (by original designation). — "Type *Venus thaca* Molina (= *V. dombeiyi* Lamarck)." [*Chama thaca* Molina, Saggio sulla Storia Naturale del Chile, p. 178. 1782. See also English translation, Vol. 1, pp. 141, 243, 1808 (Middletown, Connecticut); a different edition, 1809, pp. 167, 287. — Olsson, 1961, p. 304, pl. 41, fig. 1; pl. 53, figs. 1, 1a (as *Protothaca* (*Prothothaca*) *thaca*). Lima, Peru, to Chile. *Venus dombeii* Lamarck, illustrated by Reeve, Conch. Icon., Vol. 14, *Venus*, pl. 9, fig. 29, April, 1863. "Hab. Valparaiso Bay; Cuming." See also Riveros Zuñiga and Gonzales Reyes, Rev. Biol. Mar., Vol. 2, Nos. 2 and 3, p. 142, fig. 32 (p. 143 as *Venus dombeii*), fig. 33 (as *Venus thaca*), fig. 34 (as *Venus ignobilis*). Ancon, Peru, to Puerto Montt, Chile.]

Range. — Eocene to Recent (Frizzell). Entirely or almost entirely around the Pacific basin. Western North America from middle Miocene (944) to Recent. Recent from the intertidal zone to about 46 meters (25 fathoms).

Original description. — Shell ovate, convex, coloration white or dull; surface dull, reticulately sculptured, the radials usually stronger; sculpture more or less distinctly divided into three areas, the middle of the valves with chiefly radial, the anterior radial and scabrous, the posterior with irregularly concentric sculpture; lunule and escutcheon of the left valve, sharply circumscribed; in the type species the right valve shows no escutcheon and the margin partially overlaps that of the left valve but does not conceal the ligament; middle cardinals grooved or bifid; pallial sinus free, moderate, pointed in front; the inner margins sharply crenulated in the typical section. (Dall.)

Remarks. — Some of the west American species assigned to *Protothaca* do not have coarsely crenulated inner margins nor does the right valve overlap the left. However, many others do have crenulated margins and the right valve slightly overlaps the left one posteriorly. This latter feature, although slight, is noticeable on some specimens of *Protothaca staminea*, *P. laciniata* and *P. grata*. For these reasons we leave *P. staminea* in the typical subgenus of *Protothaca*.

Protothaca is confined in its distribution almost entirely to the borders of the Pacific basin. Frizzell in 1935 stated that about 25 species of this genus were known and several have been described since. Von Ihering (945) stated that the genus occurred in the Eocene faunas of Patagonia and that it reached California in the middle Miocene. Later, Marwick (946) outlined the route of

migration to Japan in Pliocene time and to New Zealand in the Pleistocene and this was accepted by Frizzell, 1935. In the latest check list of the Tertiary mollusks of Japan by Hatai and Nisiyama (947), three species assigned to *Protothaca* are cited as occurring in strata of Miocene age in that country.

Novathaca Habe (948) was proposed for *Chione euglypta* Sowerby from Japan, a species somewhat similar to *Protothaca staminea* Conrad.

A subgenus of *Protothaca*, *Tropithaca* Olsson (949), was recently proposed with *Protothaca grata* Say, a west American species, as type. The escutcheon is much reduced in size and the pallial sinus is shorter than that of *Protothaca* s. s.

Tuangia Marwick (950), type *Venus crassicosta* Deshayes, which occurs in New Zealand, also is very similar to *Protothaca*, but it has coarser sculpture than the west American forms.

The crenulated inner margin, more distinct lunule and narrower pallial sinus are features which serve to separate *Protothaca* from *Vencrupis* Lamarck.

Key to Subgenera of *Protothaca*

- A. Sculpture coarse, the radial usually the stronger; lunule well defined; right valve sometimes overlapping the left posteriorly; valves decidedly inflated . . . *Protothaca* s. s.
- B. Sculpture fine, the concentric strongly elevated; lunule but feebly defined; right valve not overlapping the left posteriorly; valves flattened *Callithaca*

SUBGENUS PROTOTHACA S. S.

Protothaca (*Protothaca*) *staminea* Conrad

[*Venus*]. *staminea* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, pt. 2, p. 250, pl. 19, fig. 15, 1837. Not *Cytherca staminea* Conrad, 1839. [Referred to the genus *Antigona* by recent authors. See Bull. Amer. Paleo., Vol. 25, No. 94B, p. 61, 1941.]

Tapes staminea Conrad, [?] Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11, 1878. Later Tertiary of San Diego. — [?] Orcutt, West Amer. Sci., Vol. 6, Whole No. 45, p. 70, 1889. Pacific Beach, Tertiary. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 150, 1903. "Found in the Pliocene at Pacific Beach and Russ School." — Arnold, U. S. G. S., Prof. Paper No. 47, p. 28, 1906. "Pacific Beach," "San Diego Formation."

Paphia staminea Conrad, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 173, 182, 1912. [Species attributed to Carpenter.] "San Diego-Purisima," lower Pliocene. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 157, 1924. "Pliocene" of "San Diego." — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, opp. p. 78, 1929. "San Diego Pliocene."

Vencrupis (*Protothaca*) *staminea* Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 330, 1931.

Arnold's record from San Diego Pliocene cited.

Protothaca staminea Conrad, Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 66, fig. 32, 1953. "Range: Aleutian Islands to Cape San Lucas, Baja California."

Type specimen. — Two syntype lots Nos. 55.3.14.40 and 65.5.20.123, British Museum (Natural History) (A.M. Keen, Veliger, Vol. 8, No. 3, p. 169, 1966).

Type locality. — "Inhabits the coast of California, with the above." [That is, *Venus nuttalli*, "Inhabits the coast of California, Sta. Barbara, and Sta. Diego."]

Range. — (cf.) middle Miocene; late Miocene to Recent from the Aleutian Islands to Cape San Lucas, Lower California, Mexico, from shore to 46 meters (25 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305.

Original description. — Shell suboval, or suborbicular, convex, with numerous crowded radiating striae, and finer concentric lines, most distinct on the anterior side; posterior extremity direct; ligament margin nearly parallel with the base; colour variegated with yellowish and brown, and with brown angular spots; cardinal teeth compressed; sinus of pallial impression profound. Length, one and a half inches. (Conrad.)

Remarks. — Fragments of the anterior end of a valve are present in the collections of the Los Angeles County Museum from near the Mexican boundary. The largest fragment, 29 mm long, retains the radial ribbing and lunular area. The shell characters agree well with the corresponding sculpture on valves of *Protothaca staminea* of the same size.

Two casts of a bivalve resembling this species, collected by Charles Sternberg in the San Diego Formation, are in the collections of the Academy. There is no information as to the exact locality from which they came, but the matrix, gray sandstone, is similar to that of other species which were collected near and under the Mercy Hospital foundation on Sixth Street in San Diego. The outline, traces of radial ribbing and all observable characters are similar to those of *Protothaca staminea*. The largest specimen is 65 mm long and 62 mm high.

One valve labelled as coming from Loc. 122 (LAM) Pacific Beach, may have come from beds of Pleistocene age.

This species has been recorded by several authors as occurring in the Pliocene beds at San Diego. It also is well known in beds of Pliocene, and Pleistocene age, along the west coast of North America. It apparently ranges from middle Miocene age but Loel and Corey did not cite it in their list of Temblor species.

Protothaca staminea is represented by a number of forms occurring in waters of the northeastern Pacific, including those described as *Venecrumpis petiti* Deshayes, 1839, *Tapes ruderata* Deshayes, 1853, *Tapes staminea* var. *orbella* Carpenter, 1864, and *Protothaca staminea* var. *spatiosa* Dall, 1916. The species described as *Tapes laciniata* by Carpenter, 1864, and its Pliocene relative *Paphia* (*Protothaca*) *staminea* var. *hannibali* Howe, 1922, are distinct from typical *P. staminea*. The longer pallial sinus, extending more than one half the distance from the posterior toward the anterior end, is a feature which serves to separate the present species from *P. grata* Say, a generally more southern species.

Protothaca (*Novacallithaca*) *euglypta* Sowerby,

from Japan, is more elongate in outline and the margin bears strong denticulations.

Protothaca kovatschensis Ilyina (1952) described from strata of Miocene age in Kamtschatka was compared by its author with *P. staminea*.

Protothaca staminea occurs abundantly in shallow water in bays and inlets often at depths of two or three inches in coarse, sandy, muddy bottoms and on the open coast in sand under cobbles and rocks. The ecology and growth of this species has been discussed by Smith (1953).

SUBGENUS *CALLITHACA* DALL

Callithaca Dall, Proc. U. S. Nat. Mus., Vol. 26, No. 1312, p. 364, December 29, 1902.

Protocallithaca Nomura, Saito Ho-On Kai Mus. Res. Bull., No. 13, p. 10, August, 1937. "Genotype: *Venus adamsi* Reeve, 1850." Illustrated pl. 3, figs. 4a, 4b. Japan, Recent. — See also Habe, Gen. Jap. Shells, Pelecypoda, No. 2, p. 180, September, 1951.

Type species (by original designation). — "Type, *Tapes tenerrima* Carpenter."

Range. — Late Miocene to Recent, western North America and Japan. Recent from the intertidal zone to about 46 meters (25 fathoms).

Original description. — Sculpture delicate, uniform over the disk and reticulate except in distorted individuals; lunule feebly defined with no escutcheon; the dorsal margin not overlapping in the right valve; inner margins entire, otherwise as in *Protothaca*. (Dall.)

Remarks. — This subgenus was considered to be of no taxonomic importance by Frizzell, 1935, and Grant and Gale, 1931.

The differences between the type species of *Protothaca* and *Callithaca* may be of only specific value, but the fact that the right valve does not overlap the left posteriorly, the faintly defined lunule, and the smooth inner margins of the valves of *Callithaca* are distinct features. For the present we retain *Callithaca* as a subgenus of *Protothaca*.

Key To Species And Subspecies Of *Callithaca*

- A. Posterior end elliptically curved;
height 70 to 75 percent
of the length *tenerrima*
- B. Posterior end broadly curved
(or subtruncated); height 75 to 80
percent of the length (subspecies) *alta*

Protothaca (*Callithaca*) *tenerrima* Carpenter
Plate 51, Figures 1-3; Plate 52, Figures 13, 14

Tapes tenerrima Carpenter, Proc. Zool. Soc. London for 1856, p. 200, issued January 7, 1857.

Paphia tenerrima Carpenter, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 173, 182, 1912. "San Diego-Purisima." Lower Pliocene. — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 272, pl. 22, figs. 1a, 1b, 1918. "Range. — Strait of Juan de Fuca, Washington, to San Quentin Bay, Lower California (Dall)." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci.,

Vol. 1, p. 156, pl. 30, figs. 1a, 1b, 1924. Various localities cited; range, from Pliocene to Recent.

Protothaca tenerrima Carpenter, Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 65, fig. 31, 1953. "Range: British Columbia to Magdalena Bay, Baja California."

Protothaca (Callithaca) tenerrima Carpenter, K.V.W. Palmer, Geol. Soc. Amer., Mem. 76, p. 97, 1958. [Discussion of Carpenter's species. Type specimen not found.]

Type specimen. — Location unknown to the present authors.

Type locality. — "Hab. Panama; legit Col. Jewett. Mus. Gould." [Carpenter later stated. "... *Tapes tenerrima*, Cpr., P. Z. S. July 1856, which is a Californian and not a Panamic species, as had been supposed from Col. Jewett's label". (See Rept. Brit. Assoc. Adv. Sci. for 1863, p. 531, August, 1864.)]

Range. — Late Miocene ("cf."); early Pliocene to Recent. Recent from Vancouver Island, British Columbia, to Cape San Lucas, Lower California, Mexico; beach to 46 meters (25 fathoms). Often in sandy bays and estuaries at depths of 10-16 inches beneath the surface (Fitch).

Occurrence in San Diego Fm. — C.A.S. 957, 1135, 1140, 1178, 1402, 28885, 28886. L.A.M. 104, 305, 305A, 305C. S.D. 21, 417. U.C.L.A. 294.

Original description. — *T. t. tenerrima*, albido-fusca, obovali, compressa; marginibus aequaliter excurvatis; striulis radiantibus creberrimis, antice et postice fortioribus, et lirulis acutis concentricis, plus minusve distantibus, elegantior ornata; lunula vix stria majore definita; intus, dent. card. iii. radiantibus, quorum valva in altera ii. altera i. bifidi sunt; sinu palii maximo, elongato, lateribus suberectis, parum divergentibus, apice cicatr. ant. contiguo, subrotundato; margine vix crenulato. Long. .94, lat. 1.13, alt. .38. (Carpenter.)

Remarks. — Several specimens, in various states of preservation, are present in the collections from the San Diego Formation. One specimen retaining the anterior portions of both valves came from Loc. 305A (LAM) from near the Mexican boundary. A large left valve from Loc. 305C (LAM) is 126 mm long and 92.5 mm high. The shell characters of the various specimens all appear identical with those of Recent *Protothaca tenerrima*.

Perfect specimens of *P. tenerrima* are easily separable from other west American species of this genus by the elongate, ovate, flattened shell which is sculptured with fine sharp concentric lamellae.

A subspecies, *Protothaca (Callithaca) tenerrima alta* Waterfall, described from strata of Pleistocene age in Ventura Co. California, is comparatively higher in proportion to the length.

Protothaca restorationensis Frizzell (1955) described from Pleistocene beds at Puget Sound, Washington, is intermediate in outline between *P. staminea* and *P. tenerrima*. The shell is thicker and the valves are more inflated than the latter species. *Protothaca restorationensis* occurs from Puget Sound to Halfmoon Bay, California. A specimen collected by Mrs. Jack Copsey at Loc. 33901 (CAS), Tom's Point, Bolinas Bay, California, agrees well with paratypes (Nos. 5350, 5351) of Frizzell's species in the series of type specimens in the California Academy of Sciences.

Protothaca (Callithaca) tenerrima alta Waterfall
Text-Figure 12

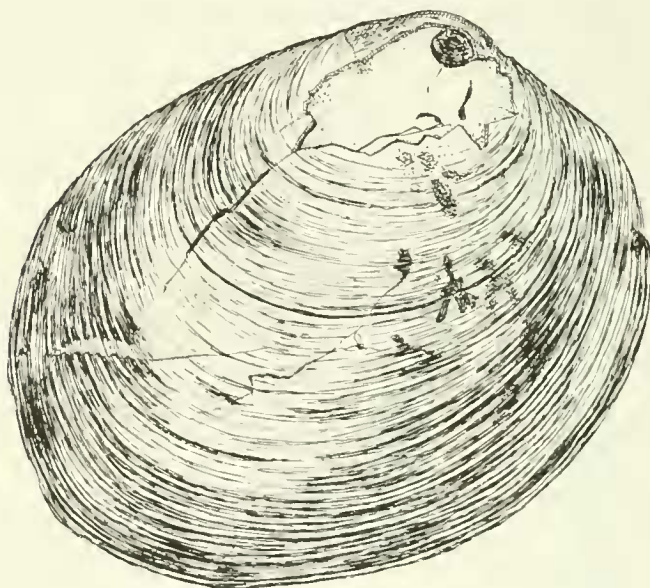
Paphia (Callithaca) tenerrima alta Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, pl. 6, fig. 1, April 6, 1929.

Type specimen. — No. 31418, Invertebrate Paleontology Collection, University of California.

Type locality. — "Saugus, U. C. Loc. 7088, Hall Canyon, two miles northeast of Ventura, California."

Range. — Middle Pliocene to Pleistocene.

Occurrence in San Diego Fm. — L.A.M. 305C.



Text Fig. 12. *Protothaca (Callithaca) tenerrima alta* Waterfall. Hypotype (Los Angeles County Museum), right valve, from Loc. 305C (LAM), near the Mexican boundary, southwestern San Diego County; Pliocene. Length 125 mm. (Drawn by Dorothy Ludlow.)

Original description. — Shell large, relatively thin, oval; beaks strongly prosogyrous, small, situated about one-sixth the distance from the anterior end; dorsal side evenly convex, rising slightly above the beaks; ventral side subtruncate; sculpture consists of more or less evenly spaced, fine concentric ridges which are, in general, spaced about 3 mm apart in the central part of the shell, between which there are, in places, similar but finer lines and faint incremental lines which become more prominent toward the periphery; radial sculpture consists of fine low ridges, less prominent than the concentric lines; and most prominent between the latter; teeth in the left valve (broken in type) three, sharp, the central one bifid; right valve unknown; hinge long, narrow, no lunule or escutcheon; pallial sinus reaching to about one-third the distance from the anterior end.

Dimensions. — Height, 96 mm, length 117 mm, diameter of left valve 25 mm. (Waterfall.)

Remarks. — A right valve 125 mm long and 103 mm high, a left valve 125 mm long and one specimen with both valves, are here assigned to *Protothaca (Callithaca) tenerrima alta*. The right valve, relatively higher in proportion to the length of typical *P. (C.) tenerrima* and

with a broadly rounded (nearly subtruncated) posterior end, is typical of the subspecies. The left valve is less typical but appears to be referable to this subspecies. A smaller specimen from the same locality is 93 mm long, 71 mm high, the convexity (both valves together) 33 mm. The posterior end of this fossil is more steeply sloping than specimens of typical *P. (C.) tenerrima* of comparable size.

The shell characters which serve to distinguish this subspecies from the typical form are more apparent on large adults than on juvenile specimens.

GENUS IRUSELLA N. GEN.

Irus of west American authors.

Not *Irus* Oken, 1815, nor *Irus* Schmidt, 1818.

Type species. — *Venus lamellifera* Conrad, 1837.

Range. — Aquitanian, early Miocene, to Recent. Recent from low tide to about 65 meters (35 fathoms).

Description. — Shell small to moderate size (40 mm long), ovate, roundly truncated posteriorly, moderately convex; sculptured with elevated, slightly reflexed, concentric lamellae which are separated by smooth interspaces 3 to 4 mm wide, and on the early portions of the valves, by fine radial striae; lunule small, ovate, crossed by the concentric lamellae; ligament external, sunken below edge of dorsal margin. Hinge plate narrow, four teeth in each valve, the anterior one smallest, the left middle and right middle and posterior ones with a slight median groove; ventral margin finely denticulated; posterior muscle impression the larger; pallial sinus extends forward a little less than half the length of the shell, roundly pointed at the end.

Remarks. — The west American species described as *Venus lamellifera* by Conrad has been placed in the genus *Irus* Oken (1956) by some authors. Oken's usage of that generic name is not available because the publication in which it appeared was ruled invalid for purposes of nomenclature by the Internat. Comm. Zool. Nomencl. in 1956, Opinion 417. Keen (1957) called attention to this ruling and suggested that *Venus lamellifera* be placed in *Notirus* Finlay (1958). The type species of that genus, *Venerupis reflexa* Gray, is sculptured with numerous fine, low, concentric lamellae and, on the specimens which we have examined, there is almost no circumscribed lunule and the early portion of the shell lacks radial striae.

Recently, Bowden and Heppell (Jour. Conch., Vol. 26, No. 4, p. 260, 1968) called attention to and accepted the usage of *Irus* Schmidt (Versuch. Conchyl. — Samml., p. 158, 1818) with the type by tautonymy, *Donax irus* Linnaeus.

The new genus here proposed, *Irusella*, is similar to *Paphonotia* Hertlein and Strong (1959), but it differs from that genus in the much thicker shell, coarser concentric lamellae, the radial sculpture confined to the early portion of the shell and the ventral margin of the interior denticulated rather than smooth. The species of this genus live in holes in rocks or in empty shells or in holes which it forms by burrowing in soft rocks. The shape is extremely variable.

Irusella lamellifera Conrad
Plate 50, Figure 11

V[enus]. lamellifera Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 251, pl. 19, fig. 19, 1837.
Petricola cordieri Deshayes, Rev. Zool., Soc. Cuvierienne, Année 1839, p. 358 (December, 1839). "California, dans les marnes calcaires, où elle se creuse des trous profonds." — Deshayes, Mag. de Zool., Livr. 6, Moll., pl. 18, 3 figs., 1840.

Venerupis lamellifera Conrad, I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 160, pl. 39, fig. 8, 1924. Monterey to San Diego, California, Recent.

Irus lamellifer Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 332, pl. 18, figs. 5a, 5b, 6a, 6b, 8, 1931. Pliocene to Recent. — Abbott, American Seashells (D. Van Nostrand Co., Inc.: New York), p. 412, pl. 31, fig. 3, 1954 (as *Irus lamellifera*). Monterey to San Diego, California.

Type specimen. — Location of type specimen unknown to the present authors.

Type locality. — "Inhabits the coast of California, with the preceding. Very rare; a single valve only was found." [The preceding species is "*V. californiana* Sby." from "Inhabits the coast of California, in muddy marshes near Sta. Diego."]

Range. — Late Miocene to Recent. Recent from Shelter Cove, Humboldt Co., to San Diego, California (1960), from low tide to 65 meters (35 fathoms).

Occurrence in San Diego Fm. — U.C.L.A. 298.

Original description. — Shell suboval, compressed; disks with about eight lamelliform concentric slightly reflected ribs, and very obscure radiating sulci; posterior extremity widely truncated; colour white; pallial impression with a profound sinus. (Conrad.)

Remarks. — A single right valve, length 27.3 mm, height, 24 mm, convexity, 12 mm, from Pliocene strata at Pacific Beach, is present in the collections of the University of California at Los Angeles. The umbonal portion and the hinge are lacking and the concentric lamellae are more irregularly spaced than typical forms of this species. This form is well within the variation of *Irusella lamellifera* resulting from its habit of boring in soft rocks or nestling in pre-existing cavities.

A large left valve of this species from San Miguel Island, California, in the Henry Hemphill collection in the California Academy of Sciences, is 42.5 mm long.

A variety of this species of Miocene age, described by Grant and Gale (1961), was said to differ from typical *Irusella lamellifera* in the more widely separated concentric lamellae and more circular shape.

Petricola cordieri Deshayes, 1839, is a synonym of *Irusella lamellifera*. Records of "*Venerupis*" *cordieri* from Port Alfred, South Africa, are referable to *Venerupis multicostata* Turton (1962).

GENUS PSEPHIDIA DALL

Psephis Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 536, 611, 640, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 22, 97, 126, 1872. — Carpenter, Proc. Acad. Nat. Sci. Philadelphia, Vol. 17, p. 56, April, 1865.

Not *Psephis* Guenée, 1854. Lepidoptera.

Psephidia Dall, Jour. Conch., Vol. 10, No. 8, p. 243, October 1, 1902. New name for *Psephis* Carpenter,

1864, not *Psephis* Guenée, 1854. — Dall, Proc. U. S. Nat. Mus., Vol. 26, No. 1312, p. 366, December 29, 1902. "Type: *Psephis lordi* Baird." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 336, 1931. Type as indicated by Dall. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 313, 1961. "Type species by original designation, *Psephis lordi* Baird."

Type species (subsequent designation for *Psephis* by Carpenter, 1865). — "Exemplum typicum: *Psephis Lordii* = *Chione Lordii*, Proc. Zool. Soc., 1863, p. 69." Same designated for *Psephidia* by Dall, 1902.

Range. — Middle Pliocene to Recent. Recent from about 9 to 91 meters (5 to 50 fathoms).

Description. — Shell small, veneriform, polished, with faint sculpture; beaks not prominent; valves inequilateral, with a narrow, feebly defined lunule and no escutcheon; inner margins not crenate; pallial sinus distinct, angular; hinge with three delicate entire cardinals in each valve, but no laterals; animal with the mantle edges fused below, the siphons short, simple; an anterior opening for the foot, which is not byssiferous. (Dall, 1902.)

Remarks. — Five species of *Psephidia* have been recorded from strata of Pliocene and Pleistocene age in California and a like number have been recorded living in west American waters between Unalaska, Alaska, to the Gulf of California. Three of these are known to be viviparous.

Key to Species of *Psephidia*

- A. Valves smooth, with lines of growth only *ovalis*
- B. Valves sculptured with concentric ridges *stephensae*

Psephidia ovalis Dall

Plate 47, Figures 5, 9; Plate 51, Figures 8, 9

Psephidia ovalis Dall, Proc. U. S. Nat. Mus., Vol. 26, No. 16, fig. 4, December 29, 1902. — Dall, U. S. Nat. Mus., Bull. 112, p. 44, 1921. Range: St. Paul Island, Bering Sea, to San Diego, California. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 161, pl. 34, fig. 4, 1924. [Same range as given by Dall.] — J. Q. Burch (editor), Min. Conch. Club South. California, No. 42, p. 16, fig. (p. 17), December, 1944. Range as given by Dall. (See also Viola S. Bristol, No. 52, p. 35, 1945.) — Abbott, American Seashells (D. Van Nostrand Co., Inc.: New York; Toronto; London), p. 411, fig. 82c [not 82b = *P. lordi*], 1954. [Copy of Dall's illustration.]

Psephidia lordi Baird variety *ovalis* Dall, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 337, 1931. Pliocene to Recent. — Faustman, Univ. Calif. Publ. Geol. Sci., Vol. 41, No. 2, p. 121, 1964 (as *Psephidia lordi* Baird subsp. *ovalis*). Rio Dell Formation; Elk River Formation; Scotia Bluffs Sandstone; Merced Formation; Etchegoin Formation.

Type specimen. — No. 163089, United States National Museum.

Type Locality. — "North side of Catalina Island, California, in 16 fathoms gravel and sand; W. H. Dall."

Range. — Middle Pliocene to Recent. Recent from St. Paul Island, Bering Sea, to San Diego, California, 29 to 91 meters (16 to 50 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305C.

Original description. — Shell small, white, polished, oval, subcompressed; surface with obsolete concentric threads near the anterior base, but over most of the disk smooth; beaks small and very low, at about the anterior third of the length; lunule elongated, extremely narrow, nearly as long as the anterior dorsal slope; escutcheon linear or none; interior white, the pallial sinus moderate, pointed; internal margin delicately straited; hinge well developed, like that of *P. lordi*, with three entire cardinals and no anterior lateral tooth. Length, 8.5; height, 6.5; diameter, 3.0 mm. (Dall.)

Remarks. — Two small valves and one larger one (5.5 mm long) in the collection from near the Mexican boundary are referred to *Psephidia ovalis*. These valves are not as ovate as the original illustration of the type specimen. However, considerable variation is observable among individuals in a series of Recent specimens. Dr. Myra Keen compared the valves from the San Diego Formation with Recent specimens of *P. ovalis* in the collection at Stanford University and considers the fossil valves to be definitely referable to this species.

Some authors have considered this form to be a subspecies of *P. lordi* Baird (1963) but in many recent works it is accorded specific status.

Psephidia stephensae n. sp.

Plate 44, Figures 21, 22, 24, 26

Description. — Shell small, rounded triangular, the beaks slightly anterior of the center, lunule and escutcheon only slightly developed; exterior with well developed, slightly irregular, concentric sculpture, the ridges rounded in the early stage but flattened on the later stage of the valves; hinge with three cardinal teeth, the central one the larger and slightly grooved; interior smooth, margins with two or three faint concentric grooves; muscle impressions typical of the genus; ligamental area small. Length of holotype 3.0 mm, height 2.7 mm.

Type specimens. — Holotype, a right valve, and paratypes a right and a left valve (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM), at the same elevation; fossils in float slump and consolidated boulders, silt and sandstone, and silt in place. San Diego Formation, Pliocene, [Loc. 305 (LAM) is 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian].

Range. — Middle Pliocene to Recent. Recent from off Santa Rosa Island, California, to San Hipolito Point, Lower California, Mexico, also Guadalupe Island, and Cedros Island, in 16 to 88 meters (9 to 48 fathoms).

Occurrence in San Diego Fm. — L.A.M. 319.

Remarks. — A number of specimens, mostly single valves, of this species are in the collection of the Los Angeles County Museum from near the Mexican boundary.

Variation in proportion of length to height can be observed in a series of specimens. Some are more highly

trigonal than others.

This new species resembles *Psephidia cymata* Dall (1964) but differs chiefly in lacking an anterior lateral tooth in the left valve. Dall did not mention this feature of the hinge in the original description of his species. Woodring (1941), p. 95) mentioned the presence of "a short anterior lateral lying close to the anterior cardinal" on Dall's species and A. M. Keen (written comm.) noticed a similar tooth on a paratype of *P. cymata* in the collection in Stanford University. The presence of a left anterior lateral is a characteristic feature of *Transennella* (separating it from *Psephidia*) and on this basis Dall's species should be assigned to that genus.

Recent specimens reported under the name of *Psephidia cymata* from off Guadalupe Island (Hanna and Strong, Proc. Calif. Acad. Sci., Ser. 4, Vol. 19, No. 1, p. 6, 1930) and from off Cedros Island (Hertlein and Strong, Zoologica, Vol. 33, pt. 4, p. 193, 1948), appear to be identical with the new species described here.

A fossil cited as "*Psephidia* n. sp.?" was reported by Woodring (1965) from strata of Pliocene age in San Joaquin Valley. It resembles "*Psephidia*" *cymata* Dall but is smaller, more trigonal, and lacks an anterior lateral tooth. The shape is much more highly trigonal than the new species from San Diego.

The shell of *Psephidia salmonea* Carpenter (1966) is generally more elongated and the concentric sculpture is much finer and more closely spaced than that on *P. stephensae* n. sp.

This species is named for Mrs. Kate Stephens, former Curator of Marine Invertebrates, San Diego Society of Natural History.

[*Psephidia barbarensis* Arnold]

Psephidia barbarensis Arnold, Smithsonian, Misc. Coll. (Quarterly Issue), Vol. 50, Pt. 4, No. 1781, p. 440 (22), pl. 58, fig. 3, December 13, 1907. — Arnold, U. S. G. S., Bull. No. 321, p. 32, pl. 12, fig. 3, 1907. "Fernando formation, Bath-house Beach, Santa Barbara," "Fernando (Pliocene)." — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, table opp. p. 78, 1929. "San Diego Pliocene."

Type specimen: Holotype No. 165,238, United States National Museum.

Type locality: "Bath-house Beach, Santa Barbara, California."

Range. —? Middle Pliocene (Waterfall), to late Pliocene or early Pleistocene.

Occurrence in the San Diego Formation. — "San Diego Pliocene" (Waterfall).

Remarks. — The only record of *Psephidia barbarensis* from the San Diego Formation is that of Waterfall. Dr. E. C. Allison and Mr. Joseph Peck, Jr., searched for but failed to find the specimen or specimens in the collections of the University of California upon which Waterfall's record was based. We have not noticed this species in any of the collections which we have studied from the San Diego Formation.

According to Arnold the diagnostic features of this little venerid are, "This species is higher and more trigonal

in outline, has a straighter anterior margin, and a less conspicuous anterior tooth than *P. lordi* Baird, which it resembles."

Keen and Bentson (1967) stated that *Psephidia barbarensis* is probably identical with *Venus rhyssomia* Gabb (1968), described from strata at Santa Barbara, California, but the type material of Gabb's species was not detected by them.

GENUS *TRANSENNELLA* DALL

Transennella Dall, Proc. U. S. Nat. Mus., Vol. 6, p. 341, 1883 (issued January 4-9, 1884). Sole species, "*Cytherea* (*Transennella*?) *conradiana* n. s." — Dall, Proc. U. S. Nat. Mus., Vol. 26, No. 1312, p. 348, 1902. "Type, *T. conradiana* Dall." p. 367, pl. 13, fig. 6 [not fig. 5 as stated on p. 411], 1902. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1240, October, 1903. "Type *T. conradiana* Dall. Florida." — Hertlein and Strong, Proc. Calif. Acad. Sci., Ser. 1, Vol. 23, No. 24, p. 376, 1939. Type by monotypy.

Type species (by monotypy). — *Cytherea* (*Transennella*?) *conradiana* Dall, 1884, p. 340. "Habitat. — Rare at Cedar Keys, in mud between tides." [Illustrated by K. V. W. Palmer, Palaeontogr. Americana, Vol. 1, No. 5, p. 302 (94), pl. 47, (16), figs. 4, 8, 10, fig. 10 in text, 1927. Florida, Pleistocene and Recent. — Abbott, American Seashells (Van Nostrand Co., Inc., New York), p. 413, fig. 83c, 1954. "South half of Florida and the Bahamas", Recent.]

Range. — Early Miocene to Recent. Recent in Atlantic and Caribbean from Florida to the West Indies; in the Pacific from Sitka, Alaska, to Chile, from the intertidal zone to about 91 meters (50 fathoms).

Description. Shell small, trigonal, with lively coloration; smooth and polished or concentrically striate; hinge with three cardinals in each valve, the middle left cardinal bifid; an elongated anterior lateral in the left valve, received in a sulcus in the right valve; lunule defined by an incised line, escutcheon not defined; nymphs without rugosities; pallial sinus angular, free below, obliquely ascending; internal margins of the valves sharply tangentially grooved with numerous sulci. (Dall, 1903.)

Remarks. — The presence of an anterior lateral tooth in the left valve serves to separate *Transennella* from *Psephidia*. The presence of strong oblique grooves on the margins of the valves is generally considered to be a characteristic feature of *Transennella*.

Species referred to this genus have been reported only from the Atlantic and Pacific coasts of the Americas. The Atlantic species, typical of the genus as mentioned by several authors, possess a deeper pallial sinus, the oblique grooving on the interior ventral margin is stronger and so far as known, they are not viviparous.

In California, *Transennella joaquinensis* Anderson and Martin was described from Temblor beds of middle Miocene age, *T. californica* Arnold was described from strata of Pliocene age, and *T. tantilla* Gould has been reported with doubt from beds of late Miocene age and definitely from late Pliocene to Recent. *Transennella herviderana* Spieker was described from beds of Miocene age in Peru, and *T. galapagana* Hertlein and Strong was

recorded from a raised beach deposit of Pleistocene age, also Recent, in the Galápagos Islands. Five species referred to *Transennella* live in west American waters in the region between Sitka, Alaska, and Chile. The species described as "*Psephidia*" *cymata* by Dall may be referable to *Transennella*.

Transennella tantilla Gould
Plate 44, Figures 20, 23, 25, 27

Venus tantillus Gould, Boston Jour. Nat. Hist., Vol. 6, p. 406, pl. 15, fig. 10, October, 1853.

Transennella tantilla Gould, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 338, pl. 15, figs. 8a, 8b, 1931. Pleistocene and Recent.

Type specimen. — "Half figured holotype" No. 169391, Museum of Comparative Zoology, Harvard University (Johnson, U. S. Nat. Mus., Bull. 239, p. 156, 1964).

Type locality. — "Inhabits Santa Barbara. Col. Jewett."

Range. — ?Middle Miocene; middle Pliocene to Recent. Recent from Sitka Harbor, Alaska, to Lat. 27° S., Lower California, Mexico, littoral zone to 36.5 meters (20 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305A, 309, 318. U.C.L.A. 1386.

Original description. — Shell quite small, rather solid, ovate-trigonal, inequilateral; beaks acute, surface smooth or faintly waved with distant concentric furrows; the dorsal margins are nearly straight, and meet at the apex in a right angle, but the posterior side is a fourth longer than the anterior; the anterior basal angle is well rounded, while the posterior is acute; basal margin gently curved. Color white, but the posterior third is stained deep slaty blue outside and in, the line of demarcation being quite abrupt and well defined; there is also a pencil of the same color inside, running from the beak to the anterior cicatrix; the rest of the interior is cream colored. (Gould.)

Length one fourth of an inch; height one fifth of an inch. (Gould.)

Remarks. — A series of specimens of this species varying in size from 2 to 7 mm in length are in the collections from San Diego and from near the Mexican boundary. The largest one is a left valve 7 mm long and 6 mm high. Large Recent specimens attain a length of 8 mm.

These specimens agree with Recent shells in shape, sculpture, and hinge. There are three cardinal teeth in each valve and in the left valve there is an anterior lateral tooth. A lanceolate lunule below the beaks is bounded by a faintly incised line. The outline of the pallial sinus on the fossils is similar to that on Recent specimens, short, rounded at the end and directed toward the anterior impression. The interior ventral margin is grooved.

"*Transennella* cf. *T. tantilla* (Gould)" (1969) was recorded from the middle part of the Altamira Shale member of the Monterey Shale probably of middle Miocene age in Los Angeles Co. Specimens, possibly *T. tantilla*, were found in Pliocene strata in the Santa Maria district. According to Woodring (1970) those fossils are smaller and have a thinner shell than Recent specimens of *T. tantilla*.

Transennella tantilla was recorded by Martin (1971) from the Merced Formation of late Pliocene age, near San Francisco, California. In a later paper Martin (1972) cited it only from the "Upper Merced" of Pleistocene age. It also has been recorded from strata of late Pliocene age in the Los Angeles area.

A small venerid in the upper Etchegoin and in the San Joaquin Formation in the San Joaquin Valley, was referred by Stewart (1973) to "*Transennella* cf. *T. tantilla* (Gould.)" He suggested that *Transennella californica* Arnold (1974) is probably identical with *T. tantilla*. Woodring (1950, p. 90), however, stated that the type specimen of *T. californica* has a more inflated umbo than that of the Recent shells of *T. tantilla*.

Hansen (1975) discussed the brooding habits and other features of living *Transennella tantilla*.

FAMILY PETRICOLIDAE D'ORBIGNY (1976)

Shell elongate to subglobose, variable in shape on account of the habit of boring in clay or soft rock, or nestling in holes in rock or in other shells; gaping at both ends; hinge narrow, with two or three cardinal teeth in each valve, of which one or more may be bifid, the posterior cardinal tooth generally small; ligament external, attached to a coarse posterior nymph; sculpture consisting of radial ribs and fine concentric lamellae which may be nearly obsolete; pallial sinus usually extending to the middle of the valve. (Adapted from Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 354, 1931 and Olsson, Mollusks of the Tropical Eastern Pacific Paleo. Res. Inst.: Ithaca, New York, p. 314, 1961.)

Range. — Cretaceous to Recent.

Remarks. — This family is represented in the Cenozoic of western North America by one genus and three subgenera.

GENUS PETRICOLA LAMARCK

Petricola Lamarck, Syst. Anim. s. Vert., p. 121, 1801.

Species cited: "*Petricola sulcata*. n. *Venus lithophaga*. Retz. In Act. Acad. Taurin. vol. 3, p. 11." "*Petricola costata*, n. *Venus lapicida*, Chemn. Conch. 10, p. 356, t. 172, f. 1664, 1665. An *Donax irus*. Linn." "*Petricola striata*. n." — Gardner, U. S. G. S., Prof. Paper 199-A, p. 116, 1943 (issued January, 1944). Type as designated by Schmidt.

Type species (by subsequent designation, Schmidt, Versuch Conchyl.-Samml., pp. 55, 176, 1818). — "Type *Venus lapicida*. X. Fig. 1664, 1665." [Chemnitz, Syst. Conchyl. Cab., Bd. 10, p. 356, Tab. 172, figs. 1664, 1665, 1788. In "Corallsteinen gefunden, dergleichen einige Schiffer bey den Westindischen Zuckerinseln als Ballast im untersten Schiffsraum eingeladen hatten". Illustrated by Warmke and Abbott, Caribbean Shells (Livingston Publ. Co.: Narberth, Pennsylvania), p. 191, pl. 44, fig. e, 1961 (as *Petricola lapicida* Gmelin).]

Range. — Eocene (Keen); Recent, widely distributed in temperate and tropical waters, from the intertidal zone to 82 meters (45 fathoms).

Description.—Shell thin, oval or elongate, often irregular, gaping. Umbones anterior but not terminal. Lunule ill defined. Sculpture dominantly radial and in the genotype divaricate or zigzag. Inner margins smooth. Ligament external, attached to nymphs. Armature of right valve usually consisting of two cardinals, the posterior of which is grooved or bifid; third rudimentary cardinal rarely present; left valve furnished either with three divergent cardinals (the middle one bifid, the remaining two simple) or with two divergent cardinals (a simple posterior and a bifid anterior); laterals absent in the normal adult. Pallial sinus narrow, as a rule, and ascending, with considerable variation in depth. (Gardner, 1948.)

This is a nestling or burrowing genus, which exhibits the variability of dwellers in such a habitat. (Gardner, 1948.)

Remarks. — One species of *Petricola* was described from strata of late Miocene age in Contra Costa Co. and two species have been reported from beds of Pliocene age in southern California. One species is known to occur in the San Diego Formation. About a dozen species and varieties of this genus have been described from west American waters in the region between California and northern Peru. About 25 species, widely distributed, are now living in temperate and tropical seas.

Warmke and Abbott mentioned that the divaricate pattern on the exterior of the type species, *Petricola lacipida*, is only a calcareous coating on the surface of the shell and is not sculpture.

SUBGENUS *RUPELLARIA* FLEURIAU DE BELLEVUE

Rupellaria Fleuriau de Bellevue, Jour. Phys., Vol. 54, p. 347. Species cited: "Repulnaire striée" and "Rupellaire reticulée" "*Venus lithophaga*. Retz." — Gardner, U.S.G.S., Prof. Paper 199-A, p. 116, 1943 [January, 1944]. "Type by elimination: *Venus lithophaga* Retzius."

Type species (designated by Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1058, 1900). — "Type *P. lithophaga* (Retzius)." [Mem. Acad. R. Sci. Turin, Vol. 3, Mém des Corresp., pp. 11, 14, figs. 1, 2, 1786. Illustrated by Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 9 (Pelecypoda, Fasc. 22), p. 445, pl. 67, figs. 20-25; 26-28 (var. *striata*), 1893. For synonymy and discussion of this species see Lamy, Jour. de Conchyl., Vol. 67, No. 4, pp. 323-328, 1923, Mediterranean, Adriatic, and Atlantic from Strait of Gibraltar to England.]

Range. — Eocene to Recent

Description. — Shell short, inflated anteriorly, more compressed and attenuated posteriorly; radial sculpture usually present over entire shell but coarser anteriorly; pallial sinus broadly rounded at the end.

Remarks. — West American species which generally have been referred to *Petricola* s. s. are referable to the subgenus *Rupellaria* as mentioned by Keen. (1977).

Petricola (*Rupellaria*) *carditoides* Conrad

Plate 44, Figures 15, 16

S[axicava]. *carditoides* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 255, pl. 20, fig. 8, 1837.

S[axicava]. *californica* Conrad, Jour. Acad. Nat. Sci.

Philadelphia, Vol. 7, Pt. 2, p. 256, pl. 20, fig. 9, 1837.

"Inhabits California near Sta. Barbara and Sta. Diego."

Petricola carditoides Conrad, Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 274, pl. 20, figs. 6a, 6b, 1918. San Francisco Bay region, from between tides to a depth of 45 fathoms. — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 50, pl. 42, figs. 6a, 6b, 1924. [Illustrations same as those of Packard.] San Juan Island, Washington. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci. Vol. 1, p. 163, pl. 34, figs. 6a, 6b, 1924. [Illustrations same as those of Packard.] "Bollinas", California. Range: Vancouver Island to Lower California. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 355, pl. 13, figs. 14a, 14b, 1931, various localities, Pliocene to Recent.

Type specimen. — Location of type specimen unknown to the present authors.

Type locality. — "Inhabits California near Sta. Barbara, where a single valve only was collected."

Range. — Pliocene to Recent. Recent from Vancouver Island, British Columbia to Scammon's Lagoon, Lower California, Mexico, from the littoral zone to 82 meters (45 fathoms).

Occurrence in San Diego Fm. — L.A.M. 107, 305. U.C.L.A. 294.

Original description. — Shell oblong - oval; disks with minute radiating lines; ligament margin straight, parallel with the basal margin; posterior extremity direct; cardinal teeth prominent. Length, an inch and a half (Conrad.)

Remarks. — An elongate left valve of this species in the collection of the University of California at Los Angeles, is 30 mm long, and 15.7 mm high, convexity, 7.8 mm. Much of the sculpture on the exterior is eroded but fine radial threads are visible on the anterior portion of this specimen. It agrees in every way with specimens of Recent *Petricola carditoides*.

A few poorly preserved specimens from Loc. 107 (LAM) are referable to *P. carditoides* and a fragment of a right valve from Loc. 305 (LAM), from near the Mexican boundary is probably referable to this species.

The shape of the shell of *Petricola carditoides* is exceedingly variable, from elongate to rounded in outline, as a result of its habitat in holes in rocks, or in other shells. The sculpture of the exterior is often almost obliterated on some fossils. Four varietal forms of this species were cited by Lamy (1978).

Petricola pedroana Conrad (1979), originally described from beds of Pleistocene age at San Pedro, California, is now generally placed in the synonymy of *P. carditoides*.

Petricola lucasana Hertlein and Strong (1980) described from "Cape San Lucas, Lower California, Mexico", is a similar species but differs in the slightly coarser radial riblets and in the different coloration of the shell. The interior of the tropical form is blackish-brown and the exterior dark orange-brown in comparison to the nearly white shell of *P. carditoides*.

Petricola buwaldi Clark (1981), described from late Miocene strata in central western California, is allied to *P. carditoides* and *P. lucasana* but possesses much coarser radial riblets. Two species, comparable to *P. carditoides*

and *P. buwaldi*, respectively, were reported by Woodring as occurring in strata of Pliocene age in the Santa Maria region.

Yonge (1982) gave an excellent discussion of the occurrence and habits of Recent *Petricola carditoides*. He concluded that this species usually settles in some pre-existing cavity which, by mechanical means, the animal enlarges to exactly fit the valves when open. The siphons extend into the water.

SUPERFAMILY TELLINACEA OKEN (1983)

A discussion of the structure and adaptations of the Tellinacea has been published by Yonge (1984).

FAMILY TELLINIDAE OKEN

Shell rounded anteriorly, more or less rostrate, obliquely truncated and gaping posteriorly; valves slightly unequal, compressed, margins usually smooth, beaks small, sculpture usually concentric; anterior adductor impression sometimes the larger; resilium subexternal; hinge plate with small cardinals and with or without laterals; pallial sinus usually long, sometimes discrepant on the two valves. Jurassic (1985) to Recent.

This family is represented in the San Diego Formation by three genera. Dall's (1986) useful synopsis of the Recent west American species has been supplemented by a compilation of the Recent species by Salisbury (1987). Many of the tropical and subtropical west American species have been discussed by Hertlein and Strong (1988), Keen (1989), and Olsson (1990). Papers by Boss (1991) deal with the subfamily Tellinae in the western Atlantic.

Key to Genera of Tellinidae

- A. Hinge usually with lateral teeth;
exterior often shiny *Tellina*
- B. Hinge lacking lateral teeth; exterior often dull
 - a. Elongate to subtrigonal;
posterior end produced
and narrowed; moderately
compressed *Macoma*
 - aa. Suborbicular to subtrigonal;
subequilateral; broad median
depression in right valve; strong
siphonal fold; moderately
inflated *Florimetis*

GENUS TELLINA LINNAEUS

Tellina Linnaeus, Syst. Nat., ed. 10, p. 674, 1758. *Tellina radiata* Linnaeus included among species cited. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol.

1, p. 357, 1931. Type as designated by Children, *Tellina radiata* Linnaeus. — Gardner, U. S. G. S., Prof. Paper 199-A, p. 94, 1943 [January, 1944]. Type as designated by Schmidt, *Tellina radiata* Linnaeus.

Type species (designated by Schmidt, Versuch Conchylien-Sammlung, pp. 51, 177, 1818). — "Typ. *Tellina radiata*." Same species also cited by Children, Quart. Jour. Sci. Lit. Arts, Vol. 14, p. 306, pl. 5, fig. 46, 1823. [*Tellina radiata* Linnaeus, Syst. Nat., ed. 10, p. 675, 1758. "Habitat in Oceano Europaeo." Illustrated by Reeve, Conch. Icon., Vol. 17, *Tellina*, sp. 8, pl. 3, figs. 8a, 8b, 1866. "Hab. West Indies." — Boss, Johnsonia, Vol. 4, No. 45, p. 235, pl. 129, figs. 1-4; pl. 130, fig. 1, 1966. Florida to the Guianas, South America. — Afshar, Geol. Soc. Amer., Mem. 119, p. 24, pl. 1, figs. 1-5, 1969. See discussion of this species by Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 45, 1952.]

Range. — Early Cretaceous to Recent. Recent from the intertidal zone to 1170 meters (640 fathoms).

Description. — Shell elongately oval to ovately trigonal; compressed, often rostrate or twisted posteriorly; beaks low; porcelaneous; surface smooth or chiefly concentrically sculptured; ligament external, opisthodontic; hinge with small cardinals and usually two laterals in each valve; pallial sinus well developed, often partly confluent with the pallial line.

Key to Subgenera of *Tellina*

- A. Shell with coarse concentric sculpture
 - a. Two lateral laminae in
both left and right
valve *Tellinella*
 - aa. One or both lateral
laminae lacking or obsolete
in left valve *Peronidia*
- B. Shell with fine concentric sculpture or smooth.
 - a. Two lateral laminae in left
and right valve *Tellina* s. s. (1992)
 - aa. One or both lateral laminae
lacking or obsolete in left valve.
 - b. Valve with internal raised
radial ridge behind anterior
muscle impression *Oudardia* (1993)
 - bb. Valves lacking internal raised
radial ridge behind anterior
muscle depression.
 - c. Pallial sinus confluent
with pallial line for
nearly entire
length *Moerella*
 - cc. Pallial sinus only partly
confluent with pallial
line *Cadella*

SUBGENUS *TELLINELLA* MÖRCH

Tellinella Gray, Mörch, Cat. Conch. Yoldi, Fas., 2, p. 13, 1853. Species cited include *T. antoni* Phillippi, *T. interrupta* Solander, *T. pulchella* Lamarck, *T. rosstrata* Linnaeus, *T. virgata* Linnaeus, and several others. — Hertlein and Strong, Zoologica, Vol. 34, Pt. 2, p. 64, August 10, 1949. Type as designated by Stoliczka. Type species (designated by Stoliczka, Mem. Geol. Surv. India, Paleont. Indica, Ser. 6, Cretaceous Fauna of South India, Vol. 3, pp. XVII, 116, 1871. — *Tellina virgata* Linnaeus [Syst. Nat., ed. 10, p. 674, 1758. "Habitat in O. Indico." Illustrated by Hanley, Thes. Conch., Vol. 1, p. 228, pl. 63, fig. 212, 1846. Indian Ocean. — Afshar, Geol. Soc. Amer., Mem. 119, p. 25, pl. 2, figs. 1-5, 1969.]

Range. — Cretaceous to Recent.

Description. — Shell with strongly rostrate posterior end and concentric sculpture consisting of sharp, elevated lamellae.

Remarks. — This subgenus is represented by several species in the Tertiary strata of California. At the present time only two species occur off California, and two occur in tropical and subtropical west American waters. Other Recent species occur in warm Atlantic and Indo-Pacific waters.

Fleming (1994) placed *Maoritellina* Finlay in the synonymy of *Tellinella*.

Tellina (Tellinella) idae Dall
Plate 53, Figures 6, 11

Tellina idae Dall, Proc. U.S. Nat. Mus., Vol. 14, No. 849, p. 183, pl. 6, fig. 3; pl. 7, figs. 1, 4, July 24, 1891. Long Beach and Catalina Island, California, Recent. Also "Fossil in the Miocene of San Diego, California." — Williamson, Proc. U. S. Nat. Mus., Vol. 15, No. 898, p. 185, 1892. Dall's record of San Diego occurrence cited. — Cooper, Calif. State Min. Bur., Bull. No. 4, p. 32, 1894. "Mioc.? — San Diego, Dall." — I.S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 164, pl. 14, fig. 4, 1924. [Reproduction of Dall's (1891) pl. 6, fig. 3] — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 358, pl. 20, fig. 12 (middle Pliocene over the Newhall railroad tunnel, Los Angeles Co.), 14a, 14b (Upper San Pedro of Santa Monica), 1931. Dall's record, "Miocene" at San Diego cited. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 84, 1929. "San Diego Pliocene". — Abbott, American Seashells (D. Van Nostrand: New York), p. 422, figs. 28h, 87a, 87b, 1954. Santa Monica to Newport Bay, California.

Type specimen. — No. 120098, United States National Museum.

Type locality. — "Habitat: Long Beach, San Pedro California."

Range. — Middle Miocene (Temblor Formation) to Recent. Recent from Santa Barbara Islands to San Pedro and Long Beach, California, in 37 to 91 meters (25 to 50 fathoms).

Occurrence in San Diego Fm. — C.A.S. 1401.

L.A.M. 107, 305, 305A, 318, 319. S.D. 27, 29. U.C.L.A. 2359.

Original description. — Shell ovate - triangular, moderately elongate, white, compressed; exterior of the right valve slightly flatter, and with more prominent sculpture than the left valve; beaks small, pointed, prominent, laterally compressed, adjacent to each other; anterior part of the shell slightly longer than the part posterior to the beaks, evenly and regularly oval, the dorsal and basal curves almost identical; posterior dorsal slope steeper, rectilinear, obliquely truncate at its termination, the basal curve (behind the perpendicular from the beaks) similar to its anterior part as far as the flexure, which is narrow but well marked, its basal end moderately incurved; behind, it rises to a strong ridge the end of which forms a rostral projection, behind which, in the right valve, is a deeply impressed line a little in advance of the posterior dorsal margin, which is strongly compressed; on the left valve there are two lines with a narrow impressed area between them, above which the dorsal margin is swollen; in front of the beaks is a narrow, acute, deeply excavated, short lunule; behind the beaks is a large, narrow, still more excavated escutcheon, most of which is excavated from the left valve, which falls short of the right valve a little; the ligament is sunken in and about half as long as the escutcheon; it is quite invisible on a lateral view of the shell; the left valve is regularly, sharply, closely, concentrically grooved, and both are obsoletely, finely, radiately striate; the margin between the impressed area of the left valve and the escutcheon is more finely grooved than the rest and has a (somewhat irregularly) denticulate dorsal edge; the right valve has the concentric sculpture more distant and, ventrally, shows distinctly elevated narrow lines with wider interspaces regularly disposed, and also bears denticulations on its posterior dorsal margin; the umbones are nearly smooth; the shell gapes but little, chiefly at the end of the rostrum; internally the surface of the valves is smooth, the muscular and pallial impressions are brilliantly polished; besides the usual marks, in the specimen under examination there are, near the posterior ventral angle of the pallial sinus, two small circular impressions and some obscure and irregular markings at the entrance of the sinus, all due, doubtless, to attachments of the mantle and probably inconstant or variable in different individuals; the anterior part of the pallial sinus nearly reaches the scar of the anterior adductor, and nearly the whole of the basal part is coincident with the line of the basal attachment of the mantle; the hinge plate is broad and subtriangular, quite strong, bearing one prominent grooved tooth between two channels; behind the posterior channel, in the left valve, is a much narrower, obscure, and little - raised tooth; the corresponding second tooth in the right valve is anterior and similarly obscure; the left valve is destitute of lateral teeth, but in the right valve there is a short, strong, elevated, subtriangular; anterior lateral close to the anterior cardinal, and a more distant and feeble posterior lateral over the posterior adductor scar. Altitude of shell, 28.5; maximum longitude, 48; diameter, 8.5 millimeters, of which 5.0 millimeters is comprised in the left valve. (Dall.)

Remarks. — This species is represented in the present collections by three nearly complete single valves and by a number of small ones and fragments of valves. The largest is a left valve from Loc. 305A (LAM), near the

Mexican boundary, 65.8 mm long, height (incomplete) 38.4 mm. A right valve, complete except for the extreme posterior end, is 57 mm long, 33 mm high, and convexity 6 mm. An impression of the larger portion of a right valve from Loc. 1401 (CAS), from the south slope of Mount Soledad, is 58 mm long (incomplete) and 34.6 mm high.

The shell of this species is characterized by the strongly rostrate posterior end and the well-developed, raised, sharp, concentric sculpture. These concentric threads are spaced a little less than 1 mm apart on the medial portion of an adult right valve. Burch (1995) pointed out that young specimens of this species are equilateral and triangular in shape with coarser sculpture than on adults.

Tellina nevadensis Anderson and Martin (1996) was placed in the synonymy of *T. idae* by Grant and Gale. The specimens in the type lot of *T. nevadensis* are large, a paratype is 72 mm long. The type specimens are higher in proportion to the length in comparison to specimens of *T. idae*. Perhaps differences in details of the two are a result of size and preservation.

Tellina idae was recorded occurring in Temblor beds of middle Miocene age by Loel and Corey, and by Stewart (1997). The latter author cited "*Tellina* cf. *T. idae* Dall" from the Temblor Formation and a species under this same caption was listed by Woodring (1998) from the middle part of the Altamira Shale member in Palos Verdes Hills, near San Pedro, California, in beds probably of middle Miocene age, and later (1950, p. 98) he cited it from the Cebada Member of the Careaga Sandstone (Pliocene). Moore (1999) recently reported "*Tellina* aff. *T. idae* Dall" from the Astoria Formation of middle Miocene age in Oregon.

A similar species is *Tellina tenuilineata* Clark (1000) which was described from near Walnut Creek, California, in beds believed to be of Oligocene age.

Tellina englishi Clark (1001) described from beds of late Miocene age is another similar species. Judging from casts of the type specimen, the shell is more elongated than that of *T. idae*. However, it may fall within the variation of the Recent species as suggested by Grant and Gale.

That *Tellina idae* may be recorded under more than one name in the literature referring to the fauna of Miocene strata appears quite possible, for Loel and Corey (1002) cited *T. idae*, *T. tenuilineata* and *T. tenuistriata* Davis (1003), all from the "Temblor Horizon."

Tellina idae has been recorded from several localities from beds of Pliocene or Pleistocene age in southern California; at San Quintín, Lower California; and by Durham from beds of late Pliocene age in the Gulf of California.

SUBGENUS CADELLA DALL, BARTSCH, AND REHDER

Cadella Dall, Bartsch, and Rehder, Bernice P. Bishop Mus., Bull. 153, p. 196, July 25, 1938. "Type: *Tellina lechiogramma* Melville." — Habe, Gen. Jap. Shells, Pelocypoda, No. 3, p. 212, 1952. "Type species: *Tellina lechiogramma* Melville (original designation.)"

Type species (by original designation). — "*Tellina lechiogramma* Melville" [*Tellina* (*Maera*) *lechiogramma* Melville, Mem. Proc. Manchester Lit. Philos. Soc., Ser. 4, Vol. 7, No. 1, p. 65, pl. 1, fig. 22, 1893. "Hab. Bombay (Abercrombie)." India. — Afshar, Geol. Soc. Amer., Mem. 119, p. 33, pl. 8, figs. 6-10, 1969. "Karachi, Pakistan."]

Range. — Late Miocene to Recent. Recent from northern Lower California to Japan, India, and South Africa.

Original description. — Shell small, broadly ovate to donaciform, rather inflated, the valves comparatively thick, white or grayish or tinged with rose. The umbones are located a third to a fourth of the entire length from the posterior end, from which the posterior margin may descend rather sharply to an obtuse, postero-ventral angle, or the posterior end may be somewhat longer and rounded; anterior to the umbones is a long slender depressed lunule. The sculpture consists of fine, closely concentric ridges, which flatten out anteriorly so that the sculpture there appears to consist of fine, evenly separated grooves. Ligament rather short, situated in a broadly lanceolate escutcheon. The hinge is typically tellinid, the left anterior and right posterior cardinal teeth being stout and triangular, with or without a slight groove; the right anterior cardinal is usually rather well developed and lamellar, while the left posterior cardinal is short and rather thin; the laterals in the right valve are well developed, while those in the left valve are fused with the margin. Interior white or suffused with pink; muscle scars suborbicular, the posterior one slightly smaller than the anterior one. Pallial sinus rather large and broad, slightly ascending, the basal margin only partly fused with the pallial line. (Dall, Bartsch, and Rehder.)

For the present *Cadella* might be placed near *Moerella*, which differs not only in shape and sculpture, but also in having a larger sinus, which is almost completely fused ventrally with the pallial line, and a larger right posterior lateral which is more closely approximated to the cardinal teeth than in *Cadella*. (Dall, Bartsch, and Rehder.)

Remarks: Dall, Bartsch, and Rehder pointed out that *Cadella* differs from *Semclangulus* Iredale (1004) in possessing an external ligament.

Cadella includes several small ovate species reported only from the Pacific and Indian Ocean. It is reported from late Miocene to Recent in California, Pliocene to Recent in Japan, and Recent in Hawaii, India, and South Africa.

Tellina (*Cadella*) *salmona* Carpenter Plate 53, Figures 2, 3, 4, 8, 16

Maera salmona Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 627, 639, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 113, 125, 1872. — Carpenter, Ann. Mag. Nat. Hist., Ser. 3, Vol. 14, p. 423, December, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 235, 1872. "Hab. San Francisco (Pac. Rail. E.E.); Neeah Bay (Swan), plentiful; Monterey, 20 fathoms (Cooper)."

Tellina (*Moerella*) *salmona* Carpenter, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 157, pl. 13, fig. 7, 1903. "Pleistocene. — San Pedro (Arnold)." "Living. — Van-

couver to Monterey (Carpenter)". — K.V.W. Palmer. Geol. Soc. Amer., Mem. 76, p. 105, pl. 13, figs. 17-19, 1958. Aleutian Islands, Alaska, to San Pedro, California. Also Pleistocene.

Tellina salmonea Carpenter, Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 276, pl. 25, figs. 3a, 3b; pl. 46 (map), 1918. Within San Francisco Bay and west of the Golden Gate, in 6¼ to 17 fathoms. — I.S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 165, pl. 44, figs. 3a, 3b, 1924. (Under subgenus *Moerella*) [Same figures as given by Packard, 1918.] "Aleutian Islands to San Pedro, California." Recent.

Type locality. — Indicated as from "Neighbourhood of S. Francisco"; "Vancouver Island, Straits of S. Juan de Fuca, and adjoining Washington Territory"; "Neighbourhood of Monterey" (Carpenter, August, 1864). "Recent. Neah Bay, Washington, Vancouver Island region (type)" (K.V.W. Palmer).

Range. — Late Miocene (Cierbo Formation) to Recent. Recent from the Aleutian Island, Alaska, to South Coronado Island, Lower California, Mexico, usually on a sand bottom, from the intertidal zone to 154 meters (84 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A, 319.

Original description. — Small, subquadrate, glossy, salmon-tinted. Beach-20 fm. (Carpenter, August, 1864.)

Supplementary description. — M. testa parva, solida compacta, subquadrata; laevi, nitente, epidermide tenui cinera induta; extus pallide, intus vivide salmonea tineta; marginibus dorsalibus rectis, ad angulum 120° separatis, umbonibus haud extantibus; marginibus antico et ventrali regulariter late excurvatis; parte postica brevissima, haud angulata, intus, dent. card. utraque valve ii., quorum unus bifidus; lateralibus v. dextr. aequidistantibus, ant. extant, post. parvo; nymphis rectis, haud conspicuis; cicatr. add. post. subrotundata, ant. subrhomboidea; sinu palii satis regulariter ovali, per iv. inter v. partes interstitii porrecto. Long. .57, lat. .45, alt. .11 poll. (Carpenter, December, 1864.)

Variet testa aurantiaca, rarius albida, rosaceo tineta. (Carpenter.)

Remarks. — About 50 single valves of this little species were collected by G. P. Kanakoff near the Mexican boundary. The largest valve is 10.3 mm long and 8 mm high. A large Recent left valve from Seven Mile Beach, San Francisco, is 14.4 mm long and 12 mm high. The pallial sinus extends in an even ellipse to about 9.9 mm from the posterior end, does not touch the anterior adductor impression and slopes posteriorly to join the pallial line at about 7 mm from the posterior end of the valve. Fresh specimens are usually tinted with the salmon coloration characteristic of this species.

The record of *Tellina solmonea* from beds of Pliocene age in Japan given by Kanehara (1905) was later referred to *Cadella lubrica* Gould by Hatai and Nisiyama (1906).

Tellina kesenensis Nomura and Hatai (1907) a Recent species in Japanese waters, compared by its authors with *Tellina salmonea*, was referred by Habe (1908) to *Cadella lubrica* Gould. *Tellina (Peronidia) solmonaeformis* Nomura and Hatai (1909) has a larger, higher shell which is more trigonal in outline than that of *T. salmonea*.

[SUBGENUS *UDARDIA* MONTEROSATA]

Oudardia Monterosata, Nomencl. Gen. Spec. Conch. Medt., p. 22, 1884, "Il tipo è la *Tellina Oudardi*, Payr." — Cossmann and Peyrot, Act. Soc. Linn. Bordeaux, Vol. 66, (Conch. Néog. 1, Aquitaine, Tome 1. Livr. 2), p. 263, 1910. " (G. - T. *Tellina compressa* Br. Viv.)," text. fig. 38, and pl. 10, figs. 21-25. — K.V.W. Palmer, Geol. Soc. Amer., Mem. 76, p. 102, 1958. "Type species by original designation, *Tellina oudardi* Payraudeau, . . ."

Type species (by original designation). — *Tellina oudardi* Payraudeau [Moll. Corse, p. 40, pl. 1, figs. 16-18, 1826. "Hab. Figari, Santa-Giulia, Favone. Rare." — Hanley, Thes. Conch., Vol. 1, p. 297, pl. 66, fig. 262, 1846 (1847). According to Monterosata this species includes *Tellina compressa* Brocchi (Conch. Foss. Subapp., Vol. 2, p. 514, pl. 12, fig. 9, 1814. "Fossile in Valle de Andona." See figs. 14, 15, 16, 1901); Ronchetti, Rev. Ital. Paleo. e strat., also Sacco, Moll. Piemonte e Liguria, Pt. 29, p. 111, pl. 23, Mem. 5, Pt. 1, p. 85, fig. 35 (holotype), 1952].

Range. — Early Eocene to Recent.

Description. — Shell small, thin, ovoid, beaks situated at about two-thirds the distance from the anterior end of the valves; one anterior lateral adjacent to the cardinals; a well developed radial ridge is present just behind the elongated anterior muscle impression; exterior sculptured with fine concentric lines of growth.

Remarks. — This subgenus has been recorded from Pliocene to Recent in western North America. However, a careful study of fossil Tertiary forms in this region may reveal the presence of *Oudardia* in beds of an earlier age.

Boss (1910) recently placed *Oudardia* in the synonymy of *Angulus* Megerle von Mühlfeld. Fourteen species living in the western Atlantic were assigned to the latter subgenus.

[*Tellina (Oudardia) modesta* Carpenter]

Angulus modestus Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 602, 639, 681, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 88, 125, 167, 1872. — Carpenter, Proc. Acad. Nat. Sci. Philadelphia, Vol. 17, p. 56, 1865 [as (*Tellina*) *Angulus modestus*.] [Full description.]

Not *Angulus modestus* Verrill. 1872.

Tellina modesta Carpenter, Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11, (later Tertiary deposits of San Diego), p. 27 [lower bed (A), San Diego Peninsula]. 1878.

Not *Tellina modesta* Sowerby, Proc. Zool. Soc. London, January, 1883, p. 31, pl. 7, fig. 1, "Hab. Port Jackson (Brazier)."

Mera modesta Carpenter, Cooper, Calif. State Min. Bur. Seventh Ann. Rept. State Mineral., p. 250, 1888. "Pl. — San Diego well."

Tellina (Oudardia) modesta Carpenter, K.V.W. Palmer, Geol. Soc. Amer., Mem. 76, p. 103, pl. 13, figs. 4-9, 1958. (Type specimens illustrated.)

Type specimen. — Syntypes No. 4245, United States National Museum. (Palmer.)

Type locality. — Indicated as "Puget's sound and the

neighborhood" (Carpenter, 1864); "Hab. in sinu Pugetiano, specimina duo juniora legit Kennedy" (Carpenter, 1865). "Recent. Puget Sound, Washington (type)." (Palmer, 1958.)

Range. — Pliocene. Pleistocene and Recent. Recent, Vancouver Island, British Columbia, to Lower California. (Dall.)

Original description. — "Like *tener*, Say; but with callus between mantle-bend and scar. White." (Carpenter, 1864.)

Remarks. — The only definite record of *Tellina modesta* in the San Diego Formation is that of Cooper. We have seen no specimens in any of the collections from that area. It was cited by E.K. Jordan as occurring in beds of late Quaternary age in San Ignacio Lagoon, Lower California. Also reported by Valentine from Timms Point Silt, lower Pleistocene, from north border of Palos Verdes Hills, Los Angeles Co., California. It appears to be rare in most collections of Recent shells.

SUBGENUS *MOERELLA* FISCHER

Donacilla Gray, List. Brit. Anim. Brit. Mus., Pt. 6, p. 39, 1851.

Not *Donacilla* Lamarck, 1819.

Moera H. and A. Adams, Gen. Rec. Moll., Vol. 2, p. 396, 1856.

Not *Moera* Huebner, 1819, Lepidoptera.

Moerella Fischer, Man. de Conchyl., Fasc. 11, p. 1147, June 15, 1887. Sole species, *Tellina donacina* Linnaeus. — Cossmann and Peyrot, Act. Soc. Linn. de Bordeaux, Tom. 64 (Conch. Néogén. de l'Aquitaine, Tome 1, Livr. 2), p. 224, 1910, "(G.-T.: T.: donacina L. Viv.)" fig. 30. — Gardner, U.S.G.S., Prof. Paper 199-A, p. 94, 1943. Type by monotypy: *Tellina donacina* Linnaeus. — Hertlein and Strong, Zoologica, Vol. 34, Pt. 2, p. 67, 1949. "Type (by monotypy); *Tellina donacina* Linnaeus." — Olsson and Harbison, Acad. Nat. Sci., Philadelphia, Monogr. No. 8, p. 125, 1953. "Type by monotypy: *Tellina donacina* Linné. Recent, coast of Europe and the Mediterranean."

Type species (by monotypy). — *Tellina donacina* Linnaeus [Syst. Nat., ed. 10, p. 676, 1758. "Habitat in M. Mediterraneo." Ref. to Gualtieri, Test., pl. 88, fig. N. 1742. — Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 12 (Pelecypoda, Fasc. 25), p. 648, pl. 91, fig. 12, 14 (typical) and 15-19 vars., March, 1898. Mediterranean; also other localities. — Keen, Treatise Invert. Paleontology, Pt. N. Vol. 2, Moll. 6, p. N618, fig. E107, 7 a-d, 1969. "Eu. — N. Am. Pac." — Afshar, Geol. Soc. Amer., Mem. 119, p. 33, pl. 8, figs. 1-5, 1969. Exmouth, England. Also from North Sea to Mediterranean. For a discussion of this species see Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 48, 1952].

Range. — Early Eocene to Recent. Recent west American species live at depths of 5 to 128 meters (3 to 70 fathoms), and perhaps deeper.

Description. — Shell rather small for the genus, transversely ovate, obscurely rostrate posteriorly. Sculpture dominantly concentric, the Recent species often rayed with colors. Umbones low, opisthogyrate. Lunule and escutcheon extremely narrow, indicated but not well

defined. Ligament external, opisthodontic. Two cardinal teeth in each valve, the anterior right and the posterior left simple and laminar, the posterior right and the anterior left stouter and bifid. True laterals not developed in the left valve, though the edges are beveled to function as laterals and are received within the lateral sockets on the right valve; the anterior lateral more elevated and closer to the umbo than the posterior. Pallial sinus confluent ventrally with the pallial line throughout the greater part of its extent. (Gardner, 1943.)

The pallial sinus extends anteriorly near to the anterior adductor impression.

Remarks. — There have been differences of opinions among authors concerning the subgeneric assignment of some west American species, whether to *Angulus* Megerle von Mühlfeld, 1811, or to *Moerella* Fischer, 1887. Gardner, 1943, and Olsson and Harbison, discussed these subgenera and assigned species from the western Atlantic, formerly placed in *Angulus*, to *Moerella*. More recently, Boss (Johnsonia, Vol. 4, No. 46, p. 300, 1966) discussed the dentition of the hinges of the type species of those two subgenera and returned to earlier authors' usage of *Angulus* to include many west Atlantic species.

The hinge of *Tellina lanceolata* Gmelin, the type species of *Angulus*, lacks a well developed posterior lateral tooth in the right valve whereas the right valve of *T. donacina*, the type species of *Moerella*, has a well developed lateral tooth.

The subgeneric assignment of some west American species including *T. carpenteri* seems open to question. We have followed the practice of Dall, Olsson, and Keen, in assigning *T. carpenteri* to *Moerella*. However, it is possible that additional studies may result in placing this species in *Angulus* or possibly in a new subgenus with this or a similar west American species as type.

Eames (1011) expressed the opinion that *Moerella* should be replaced by *Psammotaea* Lamarck (Hist. Nat. Anim. s. Vert., Vol. 5, p. 516, July, 1818), with the type species (selected by Children in 1823), *Psammotaea donacina* Lamarck with the type locality, "Habite l'océan d'Europe." This interpretation of *Psammotaea* has not been generally accepted. Keen, in the Treatise on Invertebrate Paleontology, placed *Psammotaea* in the synonymy of *Gari* Schumacher.

Tellina (*Moerella*) *carpenteri* Dall

Plate 53, Figures 1, 7, 15; Plate 56, Figure 14

Angulus variegatus Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 611, 627, 639, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 97, 113, 125, 1872. — Carpenter, Ann. Mag. Nat. Hist., Ser. 3, Vol. 14, p. 423, December, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 235, 1872. "Hab. Neah Bay (Swan); Monterey and Catalina Island, 20-60 fathoms, rare (Cooper)."

Not *Tellina variegata* Gmelin, Linn., Syst., Nat., ed. 13, p. 3237, 1791.

Tellina (*Angulus*) *carpenteri* Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1210, pp. 303, 320, November 14, 1900. "This is the *Angulus variegatus* Carpenter, 1864, not *Tellina* (*Angulus*) *variegata* Gmelin, 1792."

Tellina (*Moerella*) *carpenteri* Dall, K.V.W. Palmer, Geol. Soc. Amer., Mem. 76, p. 104, pl. 13, figs. 12-16, Dec. 8, 1958. Earlier records cited.

Type specimen. — "Syntypes. — U. S. National Museum, no. 15467 (one double and one single left valve)." (K.V.W. Palmer.)

Type locality. — Originally indicated as from "Vancouver Island, Straits of S. Juan de Fuca, and adjoining shores of Washington Territory, formerly known as "Oregon"; "neighbourhood of Monterey" and "the Sta. Barbara Group." "Type locality, either Neah Bay, Washington, or Catalina Island, California." (K.V.W. Palmer.)

Range. — Middle Pliocene to Recent. Recent, Forrester Island, Alaska (Dall), to Concepcion Bay, east coast of Lower California, in 27 to 137 meters (15 to 75 fathoms).

Occurrence in San Diego Fm. — L.A.M. 107, 305, 305A, 318, 319. S.D. 4.

Original description. — "Shape of *obtusus*: no callus; rayed with pink and yellow. 20-60 fm. Cpr." (Carpenter, August, 1864.)

Supplementary description. — *A. testa form a A. obtuso* simili, sed costa interna omnino crente, valde inaequilaterali, solidiore, nitente, rosaceo et flavido subradiatim eleganter variegata; striis incrementi concentricis, postice extantioribus; umbonibus postice flectentibus, obtusis: parte antica prolongata, regulariter excurvata; marginibus dorsali et ventrali subparallelis, subrectis; parte postica curtior, subangulata: intus, dent. card. utraque valve ii, minutis, quorum alter bifidus; v. dext. dent. lat., ant. curto, satis exstante, post. nullo; nymphis curtis, latis, parum concavis, subito sectis, valvis postea subalatis; sinu palii fere cicatr. ant. tenuis porrecto. Long. .72, lat. .42, alt. .15. (Carpenter, December, 1864.)

Remarks. — This species is represented in the collections by many single valves, most of which came from localities near the Mexican boundary. The hinge and the pallial sinus agree with those of Recent specimens of *Tellina carpenteri*. The pallial sinus ascends from the posterior adductor impression to a rounded point then slopes anteriorly forming an elliptical end which does not quite touch the anterior adductor impression, then slopes posteriorly a short distance and joins the pallial line.

There is variation in the outline of this species as was indicated by the specific name originally assigned to this species by Carpenter. Many specimens agree exactly with typical *T. carpenteri*, other large ones approach in outline the more quadrate form, *T. arenica* Hertlein and Strong (1012) a generally more southern form which may be a southern subspecies of the present one. Some specimens bear a general resemblance to *Tellina* (*Oudardia*) *buttoni* Dall but they lack the narrow elevated ridge on the interior of the anterior portion of the valves of that species.

SUBGENUS PERONIDIA DALL

Peronidia Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1210, p. 291, November 14, 1900. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1014, December, 1900.

Type species (by original designation). — "Type, *Tellina albicans* Gmelin (*nitida* auct.)." [Linn. Syst. Nat., ed. 13, Vol. 6, p. 3238, 1791. No locality cited. Ref.

to "Gault. test. t. 77. f. H?" and "B (Gault. test. t. 77. f. M?)" For illustration of *Tellina nitida* Poli see Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 12 (Pelecypoda, Fasc. 25), p. 660, pl. 93, figs. 1-5, 1898. Recent, Mediterranean and west Africa. — Afshar, Geol. Soc. Amer., Mem. 119, p. 84, pl. 35, figs. 1-5, 1969.] Range. — Eocene to Recent.

Description. — Shell without laterals, having the internal character of *Angulus* s. s., and the external character of *Eurytellina*. (Dall.)

Remarks. — This subgenus has been reported occurring in widely separated areas in the world. In Europe it has been recorded from the Eocene, and from the Aquitanian (early Miocene) to Recent, and in the same region the type species (1013) of *Peronidia* has been recorded occurring from Helvetian, middle Miocene, to Recent.

In addition to the occurrence of *Peronidia* from late Oligocene or early Miocene to Recent in western North America, and apparently the same distribution in Japan, it also has been reported occurring in beds of Miocene age in New Zealand.

Tellina (*Peronidia*) *bodegensis* Hinds

Plate 53, Figures 9, 18

Tellina bodegensis Hinds, Zool. Voy. Sulphur, Moll., Pt. 3, p. 67, pl. 21, fig. 2, 1844 (January, 1845 on cover). — Weymouth, State Calif. Fish Game Comm., Fish Bull. No. 4, p. 42, pl. 11, fig. 1, 1920. Range. "throughout California." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 168, pl. 44, fig. 5, 1924. Earlier records cited. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 362, pl. 20, fig. 13, 1931. Earlier records cited. — Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 73, fig. 39, 1953. "Queen Charlotte Islands, British Columbia, to Cape San Lucas, Baja California."

Tellina (*Peronidia*) *bodegensis* Hinds, Burch, Min. Conch. Club South. Calif., No. 43, p. 8, January, 1945. Discussion and earlier records.

Type specimen. — Holotype No. 74.12.11.372, British Museum (Natural History) (Keen, Veliger, Vol. 8, No. 4, p. 267, 1966).

Type locality. — "Inhab. Russian Bodegas. From seven fathoms, on a sandy floor."

Range. — Pliocene to Recent. Recent from Queen Charlotte Islands, British Columbia, to Cape San Lucas, Lower California, Mexico, below low tide level to 27 meters (15 fathoms). "Found on most sandy beaches along the outer coast and particularly in the coarse, shifting sand near the entrances to bays, lagoons, and estuaries." (Fitch.)

Occurrence in San Diego Fm. — L.A.M. 305A, U.C.L.A. 312.

Original description. — Testâ transversâ, oblongâ, albâ, nitidâ, concentricè striatâ; latere antico majusculo, elongato, rotundato, postico nasuto, ad extremitatem truncato, ab umbonibus subprominulo; iris acutis, versus umbones respectantibus; ligamento subinterno. (Hinds.)

Remarks. — A left valve of this species from Loc. 305A (LAM), near the Mexican boundary, is 51.6 mm long and 25.8 mm high. A right valve from Loc. 312 (UCLA), also from near the Mexican boundary, is 37.8

mm in length. These valves agree in all observable shell characters with Recent valves of *Tellina bodegensis*. The pallial sinus on the smaller of the two valves extends to within 3.5 mm of the anterior muscle impression. One of the largest specimens of a Recent shell from Morro Bay, California, in the Henry Hemphill collection of the California Academy of Sciences, is 52.3 mm long, 26.4 mm high, convexity (both valves together), 10.9 mm, the pallial sinus extends anteriorly from the posterior margin, 33.9 mm.

Tellina bodegensis differs from *T. santarosae* Dall (1914) in that the shell is thicker, more convex, less equilateral, higher in proportion to the length, the concentric sculpture is less evenly spaced and the pallial sinus is broader.

A form (1015) of *T. bodegensis* from the Sooke Formation, Vancouver Island, British Columbia, of late Oligocene or early Miocene age, closely resembles the Recent species but differs in that the truncated posterior end of the shell is narrower.

GENUS *MACOMA* LEACH

Macoma Leach in Ross's Voy. of Discovery in H. M. S. Isabella and Alexander, Ap. 2, p. LXII, 1819. Sole species, *Macoma tenera* Leach. — Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1210, p. 292, 1900. "Type, *Macoma tenera* Leach (= *Tellina calcarea* Gmelin)." — Grand and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 365, 1931. Type same as indicated by Dall. — Eames, Philos. Trans. Roy. Soc. London, Ser. B, No. 627, Vol. 235, p. 398, June 26, 1951.

Type species (by monotypy). — *Macoma tenera* Leach, 1819, p. LXII. "M. concentrice striolata, epiderme viridescens-lutea. Lat. 76° N., Long. 76° W." [= *Tellina calcarea* Gmelin, Linn. Syst. Nat., ed. 13, Tom. 1, Pars VI, p. 3236, 1791. "Habitat frequentissima in mari islandiam circumfluente, testa tenui." Ref. to "Chemn. Conch. 6. t. 13. f. 136." Reported by Chemnitz from "wohnet in unzählbarer Menge an den Ufern von Iszland und der Ferroischen Eylande."]

Range. — Eocene to Recent. Worldwide. Recent from the littoral zone to 1300 meters (711 fathoms).

Description. — Shell roundly or elongately trigonal in shape, slightly inflated, usually with a well developed posterior flexure; sculpture consisting of lines of growth, or lacking; lateral teeth lacking; pallial sinus well developed, sometimes differing in shape in the two valves.

Remarks. — A number of species of *Macoma* have been recorded from strata of Tertiary age in California, especially from Miocene to Recent. About 15 species have been recorded from beds of Pliocene age. Four species are recorded in the present paper from the San Diego Formation. This genus is represented by numerous Recent species which occur abundantly in boreal west America waters and only a slightly smaller number extend into subtropical waters or are confined to tropical west American waters. Most of the latter are referred to sub-genera which are confined to warm marine waters.

Oinomikado (1016) remarked on the pallial sinus of a number of species of *Macoma* living in Japan.

Key to Subgenera of *Macoma*

- A. Posterior area sculptured with granules *Macoploma*.
- B. Posterior area with concentric striae only
 - a. Dorsal margin behind ligament produced upward *Rexithaerus*.
 - b. Dorsal margin behind ligament not produced upward *Macoma*, s. s.

SUBGENUS *MACOMA*, S. S.

Description. — Shell subtrigonal, the periostracum conspicuous; usually colorless, or, if colored, without a color pattern; flexure well marked; the pallial sinus coalescent with the pallial line below and often discrepant in the two valves; inhabiting the cooler seas and especially boreal waters. (Dall, 1903.) Eocene to Recent.

Key to Species of *Macoma*, s. s.

- A. Pallial sinus in left valve extending to anterior adductor muscle impression
 - a. Shell usually 50 to 65 mm. long; pallial sinus in right valve usually slopes anteriorly where joining pallial line *nasuta*
 - aa. Shell usually exceeding 50 to 65 mm. in length, pallial sinus in right valve usually slopes slightly posteriorly where joining pallial line *nasuta kelseyi*
- B. Pallial sinus in left valve not extending to anterior adductor muscle impression
 - a. Pallial sinus in right valve elliptical *elimata*
 - aa. Pallial sinus in right valve subtrigonal
 - b. Pallial sinus extending to near (2 mm) anterior adductor impression; shell cuneiform in outline *inquinata*
 - bb. Pallial sinus extending anteriorly about 3/5 the length of the shell; shell elongately ovate in outline *acolata*

Macoma (Macoma) acolata Dall Plate 53, Figures 12, 13

Macoma acolata Dall, West Amer. Sci., Vol. 19, No. 3, p. 21, June 15, 1921. — Dall, Proc. U. S. Nat. Mus., Vol. 66, Art. 17, p. 19, pl. 8, figs. 2, 3, 1925. Original locality cited. — Manager, Johns Hopkins Univ. Stud. Geol., No. 11, p. 290, 1934. San Quintin Bay, Lower California, Pleistocene. — Addicott and Emerson, Amer. Mus. Novitates, No. 1925, pp. 18, 21, 1959. Three miles southeast of Punta Cabras, Lower California, Pleistocene. — Emerson and Chace, Trans. San Diego

Soc. Nat. Hist., Vol. 12, No. 21, pp. 338, 341, May 27, 1959. Tecolote Creek, San Diego, California, Pleistocene.

Macoma moesta (Deshayes) variety *acolasta* Dall, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 371, pl. 14, fig. 7; pl. 20, figs. 4a, 4b, 10, 1931. San Quintin Bay, Lower California, and southwest of Goleta, California, Pleistocene. — DeLong, Trans. San Diego Soc. Nat. Hist., Vol. 9, No. 25, p. 242, opp. p. 244, 1941. Palos Verdes Sand, upper Pleistocene.

Macoma morroensis T. A. Burch, Min. Conch. Club South. Calif., No. 47, p. 33, pl. 2, figs. 46, 47, April, 1945. "from Morro Bay, Calif."

Type specimen. — No. 333113, United States National Museum.

Type locality. — "Pliocene or early Pleistocene of San Quintin Bay, Lower California," Mexico.

Range. — Middle Pliocene to Recent in southern California; Pleistocene in southern California and in northern Lower California; Recent from Bodega Bay to San Diego, California, from the intertidal zone to 73 meters (40 fathoms).

Occurrence in San Diego Fm. — U.C.L.A. 1386.

Original description. — Shell small, inequilateral, inequivalve, posterior end somewhat bent to the right, surface smooth except for faint incremental lines which are stronger on the posterior area; beaks not prominent, nearer the posterior end; both dorsal slopes somewhat arched, anterior end evenly rounded, base slightly arcuate, posterior end very slightly rostrate; left valve more convex; hinge feeble, right valve with two small cardinals, left valve with a single bifid tooth; pallial sinus in the left valve, subovate, reaching a little beyond the middle of the valve, the lower two-thirds coalescent with the pallial line; in the right valve the sinus is almost triangular. Height 12; length 22; diameter 5.6 mm. (Dall.)

Remarks. — This species is represented in the San Diego Formation by a single specimen retaining both valves, length 25.6 mm, height, 15.4 mm. This is the first record of this species in the San Diego Pliocene. It is known to occur at several localities in beds of Pleistocene age.

The present specimen agrees in all particulars with Dall's original illustration of *Macoma acolasta* except that the pallial sinus bends farther anteriorly before joining the pallial line at an acute angle. However, the amount of variation of this feature in Dall's species is unknown. All other shell characters are so similar that we refer the present fossil to *M. acolasta*.

The shell of *Macoma acolasta* differs from that of *M. moesta* Deshayes (1017), an Arctic and boreal species, in that the shell is more elongated and the posterior end bears a gentle but distinct flexure.

Grant and Gale recorded, questionably, the occurrence of *Macoma moesta* in beds of late Pliocene age in San Joaquin Valley, California, but we have not seen specimens.

The illustrations of the type specimen of *Macoma morroensis* T. A. Burch, although not clear in detail, agree with *M. acolasta* in all observable particulars. A paratype, No. 8344, in the collections of the California Academy of Sciences, an immature specimen about 17 mm in length, agrees well with the early stages of development shown in Dall's illustration of *M. acolasta*.

Macoma (Macoma) elimata Dunnill and Coan
Plate 53, Figure 5

Macoma calcarea Gmelin, Dall. U. S. G. S., Prof. Paper 59, p. 126, pl. 14, fig. 8, 1909. "Miocene of Coos Bay, Oregon." [Pliocene] — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, table opposite p. 78, 1929. Upper Pico Formation, Pliocene. — Cummings, Touring, and Brabb, Calif. Div. Mines Geol., Bull. 181, p. 208, photo 19, No. 2, 1962. San Gregorio Member of the Purisima Formation, San Mateo Co., Calif., Pliocene. — Faustman, Univ. Calif. Publ. Geol. Sci., Vol. 41, No. 2, p. 122, pl. 1, fig. 4, 1964. Humboldt Co., Calif., also other localities, Pliocene.

Not *Tellina calcarea* Gmelin, Linn. Syst. Nat., Tome 1, Pars. 6, p. 3236, 1791.

"*Macoma* sp. nov. = *M. calcarea*, Arnold 1903," Crickmay, Jour. Geol., Vol. 37, No. 7, pp. 624, 627, 628, 631, 1929. Deadman Island, Pleistocene.

Macoma calcarea Gmelin (small var.), A. Clarke, Trans. San Diego Soc. Nat. Hist., Vol. 7, No. 4, table opp. p. 30, 1931. Timm's Point, Pleistocene. — Woodring, Bramlette, and Kew, U. S. G. S., Prof. Paper 207, p. 84, pl. 33, fig. 6, 1946. Timms Point Silt. — Woodring, Vedder, and Trumbull, also Winterer and Durham, U.S.G.S., Prof. Paper 334-H, p. 302, 1962 (as *Macoma* cf. *M. calcarea*). Los Angeles Co., Pliocene.

Not *Tellina calcarea* Gmelin.

Macoma elimata Dunnill and Coan, Nat. Mus. Canada, Nat. Hist. Papers No. 43, p. 1, figs. 1, 2 (a-e), 3, 6, (2a, 2b), December 9, 1968. — Dunnill and Ellis, Nat. Mus. Canada, Nat. Hist. Papers No. 45, p. 15, figs. 4, 2a-d; 9f, January 10, 1969.

Type specimen. — Holotype No. 46070, National Museum of Canada, Division of Mollusks.

Type locality. — "from the north end of Moresby Island, Satellite Channel, Vancouver Island, British Columbia (48° 44' N. by 120° 19' W.) . . . in silty sand at a depth of 49 meters on 7 June 1967."

Range. — Middle Pliocene to Recent. Recent from Craig, Alaska, to off Redondo Beach, Los Angeles Co., California, in 15 to 476 meters (7 to 260 fathoms), in silty and clayey sand, and sand.

Occurrence in San Diego Fm. — L.A.M. 107. U.C.L.A. 2359.

Original description. — The shell is moderately inflated, reaching its maximum thickness well anterior to the umbos. The umbos are fairly prominent and slightly raised above the dorsal margin. The shell is ovate anteriorly; posteriorly the dorsal margin is straight and steeply sloping. The anterior end is truncate. The periostracum is greenish grey and flaky and is little eroded except around the umbos. The shell is chalky white and is covered with fine, concentric growth lines. The posterior dorsal margin has a flattened, concave escutcheon. The valves are flexed toward the right posteriorly.

The interior is white with a low polish and silky lustre. The pallial sinuses are discrepant, long in the left valve (stopping just short of the anterior adductor scar), much shorter and lower in the right valve. Both pallial sinuses loop back along the pallial line and are confluent with it beneath the umbos. The posterior cruciform

muscle scar occurs near the ventral - posterior tip of the pallial line and divides into two parts, with a small anterior element. The anterior cruciform scar lies immediately ventral to the pallial line. There are two cardinal teeth in each valve. The left anterior and right posterior teeth are projecting and bifid, while the right anterior and left posterior teeth are projecting, lamellar, and fragile. The left posterior tooth is the thinnest and frequently breaks off when the valves are opened. The holotype is 27.2 mm long, 20.7 mm high, and 9.6 mm thick, (both valves).

Remarks.—Two specimens, the larger one 27.2 mm long, from the San Diego Formation, are present in the collections of the University of California at Los Angeles. These are identical with a series of 29 specimens, the largest one 32 mm long, from Loc. 3 (CAS) in strata of Pliocene age at Coos Bay, Oregon, from which beds a specimen was illustrated by Dall under the name of *Macoma calcaria*. One imperfectly preserved specimen from Loc. 107 (LAM) is comparable to *M. elimata*. Specimens cited as *M. calcaria* by Waterfall from the upper Pico Formation in Ventura Co., California, also are referable to *M. elimata*.

Macoma elimata resembles *M. calcaria* Gmelin but differs from that species in the straighter dorsal margin posteriorly and especially in the somewhat flattened or slightly concave escutcheon (see Dunnill and Coan, 1968, figs. 2a-e, and illustrations of *M. calcaria* Gmelin, figs. 2f, 9, 10). It apparently does not attain the size of large specimens of *M. calcaria*, that is, about 33 mm in length in comparison to 50.8 mm. The spermatozoa of Recent specimens of the two also are said to differ.

Madsen (1018) pointed out that specimens of *M. calcaria* from the Atlantic coast of the eastern United States are generally more elongate in outline. This is well shown in Gould's illustration (1019) of "*Tellina proxima*" from that region.

The *Macoma calcaria* group apparently had its origin in the northern Pacific as suggested by MacNeil (1020). Hatai and Nisiyama (1021) reported *M. calcaria* from Japan from strata believed to be of Miocene age and they also mentioned a subspecies, *M. (s. s.) calcaria izurensis* Yokoyama from the Akadaira Formation of Oligo-Miocene age. Another subspecies, *M. calcaria yokohamaensis* Aoka (1022) was described from the Nakazoto Formation of late Pliocene age. In England, the *M. calcaria* group is reported to make its first appearance in the Red Crag beds, to which many authors assign an early Pleistocene age. Malatesta (1023) recently discussed the occurrence and identification of *M. calcaria* and subspecific forms in the Pleistocene deposits of Italy and adjacent regions.

Two varieties of *Macoma calcaria* from the Arctic were described by Soot-Ryen (1024). An excellent discussion of the variation of the shell and the habitat of *M. calcaria* was given by Odhner (1025) and later by MacGinitie (1026).

The species described as *Tellina albaria* Conrad (see Moore, E., U. S. G. S., Prof. Paper 419, p. 80, pl. 28, figs. 8, 9, 12; pl. 29, fig. 9, 1963), from Astoria, Oregon, of middle Miocene age, are somewhat more elongate in outline, and may be a precursor of *M. elimata*. *Macoma twinensis* Clark, from beds said to be of late Oligocene age, is another member of this group.

Macoma (Macoma) inquinata Deshayes
Plate 52, Figures 1, 10

Tellina inquinata Deshayes, Proc. Zool. Soc. London for 1854, p. 357 (issued May 16, 1855). — Sowerby, Conch. Icon., Vol. 17, *Tellina*, species 164, pl. 30, fig. 164, 1867. "Hab. Vancouver's Island." Reproduction of Sowerby's figure by Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 367, pl. 20, fig. 5, 1931. Pliocene to Recent.

Macoma inquinata Deshayes, Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 204, 1909. Quillayute Formation, western Washington, Pliocene. Also "Purissima-San Diego." — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 278, pl. 23, Figs. 2a, 2b, 3a, 3b; pl. 24, Figs. 1a, 1b; pl. 48 (map of distribution). 1918. "Bering Strait to Monterey, California (Dall)." Recent. — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 54, pl. 32, figs. 2a, 2b, 3a, 3b, 1924. "San Juan Island, Wash." "Bering Strait to Monterey, Calif.; Japan." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 172, pl. 45, figs. 2a, 2b, 3a, 3b, 1924. Pliocene to Recent. (Illustrations same as in preceding reference.) — Salisbury, Proc. Malacol. Soc. London, Vol. 21, pt. 2, p. 85 (in text), pl. 12, fig. 5 (type), 1934. "from the Columbia River."

Type specimen. — British Museum (Natural History) (A.M. Keen, written comm., January 24, 1967.)

Type locality. — "Hab. Columbia." ["from the Columbia River" (Salisbury).]

Range. — ? Late Miocene; Pliocene to Recent. Recent from Bering Strait to San Pedro, California, from intertidal zone to 110 meters (60 fathoms).

Occurrence in San Diego Fm. — L.A.M. 124. U.C.L.A. 1386.

Original description. — T. testa trigona, crassa, solida, depressiuscula, inaequilaterali, sub epidermide squallide fusca albobusca, ferrugineo inquinata, transversim irregulariter striata, intus candida; latere antico late obtuso, subsemicirculari, superne parum declivi; latere postico cuneiformi, attenuato, superne recto et declivi, extremitate oblique truncato, inferne oblique angulato, flexura parum perspicua; ligamento praelongo, incrassato; cardine bidentato, dentibus lateralibus nullis; sinu pallii magno, profundo, superne gibboso, deinde declivi et apice acuto. (Deshayes.)

Remarks. — Two valves of *Macoma inquinata* from Balboa Park in the collections of the Los Angeles County Museum agree in all details with Recent specimens of this species. The larger one, a right valve, is 44 mm long, 32.8 mm high, and the convexity (one valve), 10.2 mm. The portion of the pallial line visible is identical with Recent forms. A Recent large right valve from Unalaska Island, Alaska, in the collections of the California Academy of Sciences, is 65 mm long, 45.6 mm high, convexity (one valve), 12.2 mm.

Two small valves from Balboa Park, San Diego, in the collections of the University of California at Los Angeles, are referred with question to *Macoma inquinata*. The left valve is incomplete, the right one measures, length, 21 mm, height, 16 mm, convexity, 4.2 mm. These compare favorably with juvenile specimens of *Macoma inquinata* except that the pallial sinus on the right

valve extends closer to the anterior adductor muscle impression. There is a possibility that these fossils are referable to the form described from the Etchegoin Pliocene, *Macoma affinis plena* Stewart (1927). The general outline is similar but the shape of the pallial sinus of *M. a. plena* is not well known. We, therefore, provisionally refer the present fossils to the Recent *M. inquinata*. Based on external features these fossils hardly differ from shells of *M. balthica* Linnaeus of the same size.

This is the first record of the occurrence of *Macoma inquinata* in the San Diego Formation but the species is known to occur in beds of Pliocene age elsewhere on the Pacific Coast.

There has been confusion of *Macoma inquinata* with *M. irus* Hanley (1928) which was described without information as to the locality from which it came. Later it was attributed to "Guinea?" by its author. Hanley stated, "Evidently a perforating species, allied to the *Petricola ochroleuca* of Lamarck, the true *Tellina fragilis* of Linnaeus's collection." Salisbury (1929) concluded from a study of type specimens in the British Museum of Natural History that *M. irus* is identical with *M. inquinata* and with the species described as *Tellina contabulata* Deshayes (1930) from Chinese seas, which locality Salisbury believed is erroneous for that species. However, Keen (1931) recently has shown that the west American species should bear the name *Macoma inquinata*. Some records of *Macoma inquinata* from Japan have been assigned to *Macoma anser* Oyama (1932).

Macoma inquinata arnheimi Dall (1933), described from Alaskan waters, has a higher and more rounded shell than the typical form. Faustman, 1964, reported this subspecies from the Rio Dell Formation in Humboldt Co., California.

Macoma inquinata affinis Nomland (1934), described from beds of Pliocene age in San Joaquin Valley, California, attains a larger size than *M. inquinata*, the height is greater in proportion to the length, and the pallial sinus does not extend so close to the anterior adductor muscle impression. This form bears a general resemblance to the Japanese *M. anser* Oyama but the oriental form is more rounded, the pallial sinus in the left valve is more angulated above and in the right valve it is more distant from the anterior adductor muscle impression.

A fossil form cited as *Macoma* aff. *M. inquinata* Deshayes, was reported by Hickman (1935) from beds believed to be of Oligocene age in Oregon.

Macoma (Macoma) nasuta Conrad
Plate 53, Figure 10; Plate 54, Figure 6

Tellina. *nasuta* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 258, 1837.

Not *Tellina nasuta* Conrad, in J. D. Dana, U. S. Exped. (Wilkes), Vol. 10, Geol., p. 725, October, 1849. Renamed *Tellina subnasuta* by Conrad in 1865.

Macoma nasuta Conrad, Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11, "Later Tertiaries," San Diego; p. 27, "sand bed (B)," San Diego peninsula, 1878. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 163, 1903. "Pacific Beach." and "San Diego (Arnold)," Pliocene. — J. P. Smith,

Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 171, 181, 1912. "Purisima-San Diego." Pliocene. — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 279, pl. 23, figs. 1a, 1b, 1c, 1d; pl. 49 (distribution), 1918. San Francisco Bay area. Range, Aleutian Islands, Alaska, to Lower California. — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 53, pl. 32, figs. 1a, 1b, 1c, 1d, 1924. (Same illustr. as shown by Packard.) Kodiak Island and Cook Inlet, Alaska, to Scammon's Lagoon, Lower California. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 174, pl. 45, figs. 1a, 1b, 1c, 1d, 1924. "San Diego," Pliocene. Also other records. — Waterfall, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 3, opp. p. 78, 1929. "San Diego Pliocene." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 366, 1931. "Middle Pliocene of Pacific Beach, San Diego (Arnold, 1903)." — Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 74, fig. 40, 1952. "Kodiak Island, Alaska, to Cape San Lucas, Baja California," Recent.

Type specimen. — Syntype No. 1861.5.21.158, British Museum (Natural History). (See A. M. Keen, Veliger, Vol. 8, No. 3, p. 170, 1966.)

Type locality. — "Inhabits coast of California near Sta. Diego."

Range. — Oligocene (Loel and Corey); middle Oligocene (Weaver); early Miocene to Recent. Recent from Kodiak Island, Alaska, to Cape San Lucas, Lower California, from intertidal zone to about 46 meters (25 fathoms). "mostly found in heavy mud or muddy sand of sheltered bays, lagoons and estuaries," at depths of four to eight inches beneath the mud (Fitch).

Occurrence in San Diego Fm. — C.A.S. 957, 1178, 1400. S.D. 21, 80.

Original description: Shell ovate, compressed, smooth but not polished; anterior side dilated; posterior side cuneiform, extremity truncated, much above the line of the base; fold carinated on the superior valve; beaks central, slightly prominent; epidermis extremely thin and deciduous, finely wrinkled, brown; pallial impression of the left valve joining the anterior cicatrix at its lower posterior angle. Length, an inch and three quarters. Height an inch and a third. (Conrad.)

Remarks. — A few specimens, none perfectly preserved, were collected in the San Diego Formation. These do not differ from Recent valves of *Macoma nasuta* in adjacent marine waters.

This species occurs without change throughout the latter half of the Cenozoic in western North America. It is characterized by the nearly centrally placed beaks and bent, obliquely pointed, posterior end. The pallial sinus in the right valve extends to the anterior adductor impression but in the left valve it extends anteriorly, then slopes to and coalesces with the pallial line at about two-thirds the length of the shell. This varies, and in occasional specimens the sinus slopes slightly posteriorly before joining the pallial line.

Macoma jacalitosana Arnold (U. S. G. S., Bull. 396, p. 65, pl. 16, fig. 2, 1909 (issued January 15, 1910), described from the Jacalitos Formation of early Pliocene age, in the San Joaquin Valley, California, is a similar form.

A Recent species in Japanese waters formerly cited as *Macoma nasuta* is now referable to *M. tokyoensis* Makiyama (1936). It is smaller and has a differently shaped

pallial sinus than that of *M. nasuta*.

Macoma nasuta was recorded by Kanehara (1937) as occurring in beds of Pliocene age in Japan but it is not among the species from the Cenozoic of Japan cited by Hatai and Nisiyama (1938).

Macoma aomoriensis Nomura (1939) and *M. ishioriensis* Aoka (1940), described from Miocene beds in Japan, were compared by their authors with *M. nasuta*.

Macoma nasuta also has been recorded from late Tertiary strata in the Schmidt Peninsula, Kamtschatka, by Khomenko and by Slodkewitsch (1941). However, the posterior end shown in illustrations by the latter author is less pointed and the shell is correspondingly more suborbicular in outline than is that of *M. nasuta*.

Macoma nasuta, known as the "bent-nost clam," is used for food along the coast of California. According to Fitch, this clam always lies on the left side and its siphons are extended to the surface for feeding and are freely withdrawn and re-extended to a different spot.

Macoma (Macoma) nasuta kelseyi Dall

Plate 52, Figures 5, 9, 11, 12

Text-Figure 13

Macoma kelseyi Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1052, pl. 49, fig. 7, December, 1900. — Schuchert, Dall, et al., U. S. Nat. Mus., Bull. 53, Pt. 1, p. 381, 1905. "Pleistocene. City Park, San Diego, California." — I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 53, 1924. "Known alive only from off Brown Island, Wash., in 3-4 fathoms." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 171, 1924. Earlier locality records cited.

Macoma nasuta kelseyi Dall, Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 222, pp. 65, 87, pl. 20, figs. 2, 8 (Graciosa Ridge, 2.9 miles south of Orcutt, California), 1950. Also, Balboa Park, San Diego Pliocene.

Type specimen. — No. 147690, United States National Museum.

Type locality. — "Pleistocene of San Diego, California, obtained in the City Park by Dr. R. E. C. Stearns." [Pliocene.]

Range. — Middle Pliocene (San Diego Formation; Careaga Formation of Santa Maria district) to Recent. Recent from Puget Sound to Halfmoon Bay, California, (and probably extending over most of the range of *Macoma nasuta*), in 5 to 7 meters (3 to 4 fathoms) and perhaps deeper.

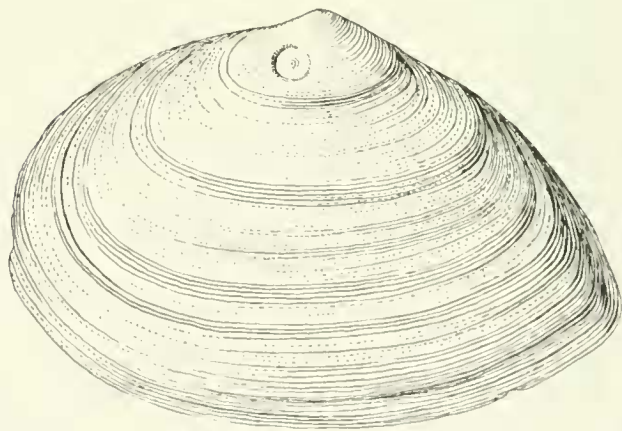
Occurrence in San Diego Fm. — C.A.S. 1402, 1415. L.A.M. 124, 323. S.D. 4, 29, 79, 80, 3206, 5679. U.C.L.A. 302, 1383, 1386.

Original description.—Shell large, solid, heavy, compressed, slightly flexed; beaks subcentral, prominent, pointed; anterior end evenly rounded into an arcuate base and dorsal margin; posterior end lanceolate, the dorsal margin nearly rectilinear; surface sculptured only by strong, rather irregular lines of growth; hinge-plate short, broad, and strong; teeth normal, elongated, large; pallial sinus discrepant in the two valves; left valve with the upper part of the sinus sinuous, extending from the posterior to the anterior adductor, behind which is a thickened, obscure ray; right valve with the sinus short,

gibbous, the anterior end rounded, thence the line curves backward before coalescing with the pallial line below; in the left valve the sinus is coincident with the whole of the pallial line below. Long. 86, alt. 56, diam. 20 mm. (Dall.)

Remarks. — A number of paired and unpaired valves of this subspecies are present in the collections from the San Diego Formation. A large valve, from Balboa Park, is 87 mm long, 59 mm high, convexity (one valve), 10.5 mm. The largest specimen in the collections, a right valve from Loc. 124 (LAM), below Snyder's Continuation School, is 106.8 mm long and 77 mm high. The pallial sinus joins the pallial line 75 mm from the posterior end of the valve.

The very large size, thicker shell and slightly bent posterior end are characters included as a basis upon which the present form was separated by Dall as a subspecies of *Macoma nasuta*. Dall also believed that the subspecies *M. n. kelseyi* differed in the character of the pallial sinus in the right valve which he stated bent posteriorly before coalescing with the pallial line. Examination of a number of right valves reveals that there is variation in this character. In some specimens of *M. n. kelseyi* the pallial line does, in others it does not, bend posteriorly before joining the pallial line. Hertlein and Strong (1942) mentioned that this character is variable and considered it open to question whether *M. n. kelseyi* represents a species, subspecies or merely a very large form of *M. nasuta*. The present authors are inclined to the latter view but it is possible that this large form may have ecological or stratigraphic significance and we therefore favor its retention as a subspecies, at least for the present.



Text Fig. 13. *Macoma (Macoma) nasuta kelseyi* Dall. Hypotype (San Diego Society of Natural History), left valve, from Loc. 29 (SD) south of Laurel Street bridge, Balboa Park, San Diego; Pliocene. Length 86.8 mm. (Drawn by E. H. Quayle.)

This subspecies occurs in the Careaga Sandstone, of Pliocene age, in the Santa Maria district and in Pliocene beds at Cedros Island and at Bahía Tortolito (Turtle Bay), Lower California, as well as at San Diego. Addicott and Emerson (1943) reported this subspecies from beds of Pleistocene age at Punta Cabras, Lower California (Lat.

29° 57' N.). A Recent large right valve from Halfmoon Bay, California, is 90.8 mm in length. It appears quite probable that this subspecies may occur over much if not all the range of *M. nasuta*.

SUBGENUS *MACOPLOMA* PILSBRY AND OLSSON

Macoploma Pilsbry and Olsson, Proc. Acad. Nat. Sci. Philadelphia, Vol. 93, p. 68, September 9, 1941.

Type species (by original designation). — "Type *Macoma ecuadoriana* new species." [*Macoma (Macoploma) ecuadoriana* Pilsbry and Olsson, 1941, p. 69, pl. 19, fig. 5. "Canoa formation, Punta Blanca," Ecuador, Pliocene.]

Range. — Pliocene to Recent, eastern Pacific. Recent, tropical eastern Pacific.

Original description. — Shell elongate, nearly equi-valve, the left valve a little larger and more convex than the right; surface with the granulation of *Periploma*, developed most strongly on the posterior area, finer or absent from the rest of the surface; hinge of *Macoma*, with a small cardinal tooth in the left valve and no laterals. (Pilsbry and Olsson.)

Remarks. — The subgenus *Macoploma* differs from all other subgenera of *Macoma* by the presence of granules on the posterior area and sometimes over the whole shell, similar to *Periploma* and *Thracia*.

The subgenus *Macoploma* is here recorded for the first time from strata of Pliocene age in California. It also is known to occur in strata of Pliocene age in Ecuador and Costa Rica and in sands of late Pleistocene age at San Pedro, California.

Macoma (Macoploma) medioamericana Olsson
Plate 52, Figures 6, 8

Macoma (Macoploma) medioamericana Olsson, Bull. Amer. Paleol., Vol. 27, No. 106, p. 196 (44), pl. 17 (4) fig. 8, December 25, 1942. Cited on p. 242 (90) as "*Macoma (Macoploma) medioamericana*."). — Hertlein and Strong, Zoologica, Vol. 34, Pt. 2, p. 93, 1949. "Arenas Bank, Gulf of California, to Panama," in 29 to 82 meters.—Keen, Sea Shells of Tropical West America (Stanford University Press), p. 180, fig. 426, 1958. "The Gulf of California to Panama, intertidally and offshore in depths to 45 fathoms; rare."

Psammacoma (Macoploma) medioamericana Olsson, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 416, 1961. Gulf of California to Panama.

Type specimen. — No. 5004, Paleontological Research Institution, Ithaca, New York.

Type locality. — "Pliocene. Quebrada Peñitas, Costa Rica."

Range. — Pliocene to Recent. Recent from the Gulf of California to Atacames, Ecuador, from intertidal zone to 82 meters (45 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305A. Original description. — Shell of medium or large size, elongate, delicate; the valves are subequal, the left being slightly larger and more convex than the right which

is somewhat flexed or depressed in the middle; beaks, placed at the posterior one-third, are small and pointed; anterior side nearly twice the length of the posterior, obliquely rounded at the end; posterior side somewhat narrowed, obliquely truncated at the end; surface is marked with lines of growth, smoother in the middle, coarse and more or less granulose on the sides; each valve has a narrow, submarginal zone at the posterior end, its surface earthy in appearance and bordered anteriorly by a line of coarse granules; hinge unknown. Length, 62 mm.; height, 30 mm.; diameter, 12 mm. (Olsson.)

Remarks. — A left valve 65 mm long and 32.8 mm high, in the collection from Loc. 305 A (LAM) near the Mexican boundary, agrees in all observable shell characters with *Macoma (Macoploma) medioamericana* Olsson. The shell is somewhat worn but granules are present on the posterior area and along the anterior ventral margin. The pallial sinus on the present specimen is obscured by hard matrix. The hinge bears two cardinal teeth.

The present specimen resembles the illustration of the type specimen of *M. ecuadoriana* described from strata of Pliocene age in Ecuador. *Macoma medioamericana* and *M. ecuadoriana* are similar as pointed out by Hertlein and Strong. According to Olsson the shell of *M. medioamericana* is proportionately longer than that of *M. ecuadoriana* and "It differs also by its coarser, more earthy, or *Thracia*-like granulation of the surface on the posterior submargins." The granulation on *M. ecuadoriana* was originally described as present on the posterior area but fine or lacking elsewhere.

An imperfect left valve of a *Macoma*, 20.6 mm long and 14.4 mm high, from Loc. 305 A (LAM) near the Mexican boundary, is comparable to *Macoma medioamericana* Olsson. No granules are observable on the posterior area but this may be due to erosion of the shell surface. The shape and growth lines agree with a Recent left valve of *M. medioamericana*, 33.3 mm long from Loc. 27557 (CAS) near Punta Arenas, Costa Rica. The hinge of the fossil specimen has a similar grooved anterior cardinal tooth but what was probably the thin posterior cardinal lamella is represented only by a low eroded remnant.

Well preserved specimens of *M. medioamericana* collected by George Kanakoff from sands of late Pleistocene age at San Pedro, California, agree exactly with Recent specimens of that species from the Gulf of California and Central America.

Recent specimens of this species have two cardinal teeth in the hinge of each valve, the posterior tooth usually thinner and more lamellar than the anterior one. The pallial sinus in a left valve 100 mm long ascends rather high to a slightly flattened curve beneath the beak then descends to a rounded point about 68 mm from the posterior end of the valve and then extends posteriorly to where it joins the pallial line about 44 mm from the posterior end of the shell.

SUBGENUS *REXITHAERUS* CONRAD

Rexithaerus Conrad in Tryon, "Catalogue of the family Tellinidae," Suppl., Amer. Jour. Conch., Vol. 4, No. 5, p. 104, May 6, 1869. Species cited: "*M. secta*, Conrad" (*T. ligamentina*, Desh. in synonymy), and "*M. denticulata*, Deshayes" (*T. inaequalis*, Sowb. in

synon.). — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1045, December, 1900.

Type species (designated by Dall, Proc. U. S. Nat. Mus., Vol. 32, No. 1210, p. 292, November 14, 1900.) — "Type, *Macoma secta* Conrad." [= *Tellina secta* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 257, 1837. "Inhabits muddy marshes; Sta. Diego." Illustrated by I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 178, pl. 44, fig. 8, 1924. "Vancouver Island to the Gulf of California. Also Pliocene and Pleistocene. — Weymouth, State Calif. Fish Game Comm., Fish Bull. No. 4, p. 44, pl. 12, figs. 3 and 4; pl. 13, fig. 1, 1920. California coast. — Fitch, same series, Fish Bull. No. 90, p. 75, fig. 41, 1953. "British Columbia to Cape San Lucas, Baja California."]

Range. — Miocene to Recent. Recent from the Gulf of California to Japan.

Description. — Shell large, inequivalve, with a smooth surface, a large and strong deep-set ligament, behind which the dorsal margin is conspicuously produced upward. (Dall, 1900.)

Remarks. — This subgenus is represented in the San Diego Formation by one species and one subspecies. Three species have been cited from the late Tertiary of California.

Key to Species And Subspecies of *Rexithaerus*

- A. Beaks on adult specimen
about 25 mm. from posterior
end; not strongly rostrate
posteriorly *indentata*
- B. Beaks on adult specimen about
30 mm. from posterior end;
strongly rostrate
posteriorly (subspecies) *tenuirostris*

Macoma (Rexithaerus) indentata Carpenter

Plate 52, Figures 3, 4, 7

Macoma Indentata Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 611 ("S. Diego"), 639 (indicated as from "The region between S. Diego and S. Pedro"), issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 97, 125, 1872.—Carpenter, Proc. Calif. Acad. Sci., Vol. 3, p. 208, 1866. "Hab. San Pedro, (young, living, Palmer;) large, dead valves, Cooper." — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11, "later Tertiary" of San Diego; p. 27, "sanded (B)" about 12 ft. thick, over Bed (A), San Diego Peninsula, 1878, —Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 161, pl. 16, fig. 1, 1903. Several localities cited, Miocene to Recent. — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 277, pl. 25, fig. 4, 1918. "San Francisco to Lower California," Recent.—I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 55, pl. 41, fig. 4, 1924. (Reproduction of figure given by Packard, 1918.) Recent. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 178, pl. 44, fig. 4, 1924. (Under section *Rexithaerus*). (Reproduction of figure given by Packard, 1918.) "Santa Barbara, California to

Lower California," Recent. Also Pliocene and Pleistocene in California.

Macoma (Rexithaerus) indentata Carpenter, K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 109, pl. 16, figs. 1, 2, 1958. (Type specimen illustrated.) "Recent. San Pedro, California (type); Puget Sound, Washington, to Lower California (Dall.)" Also Miocene to Recent.

Type specimen. — No. 15229, United States National Museum.

Type locality. — "Recent San Pedro, California (type)" (K. V. W. Palmer, 1958.)

Range. — Late Miocene to Recent. Recent from Puget Sound, Washington, to Cholla Bay (1044) in the Gulf of California, Sonora, Mexico, in 15 to 46 meters (9 to 25 fathoms), in sandy mud or in sand.

Occurrence in San Diego Fm. — C.A.S. 1186, 28892. L.A.M. 305, 305A, 319. U.C.L.A. 294, 2359.

Original description: "Like *secta*, jun., but beaked, indented, and ventrally produced." (Carpenter, 1864.) Long. 2.20, lat. 1.40, alt. 0.56 (Carpenter, 1866.)

Remarks.—This species is represented by a few specimens in the collections from the San Diego Formation. The most perfect one, a right valve from near the Mexican boundary, in the collections of the Los Angeles County Museum, is 55.2 mm long and 33.3 mm high. It agrees in all essential shell characters with Recent specimens of this species.

The subspecies *Macoma indentata tenuirostris* Dall is decidedly more elongated than the typical form.

Macoma indentata flagleri Etherington (1045) described from beds of middle Miocene age in western Washington was said to be characterized by the "slightly more prominent beak and the posterior fold is only slightly developed on it as compared with the recent form."

Arnold mentioned a probable relationship between *Macoma indentata* and the species which he described as *Macoma vanvlecki* (1046) from beds of Pliocene age in the San Joaquin Valley. Grant and Gale suggested that Arnold's species was probably but a variety of *M. indentata*. However, an examination of a cast of the type specimen of *M. vanvlecki* shows it to differ from the Recent species as stated by Arnold; namely, in the much longer and much more convex form. The fossil which Nomland (1047) illustrated under the name of *Macoma vanvlecki* from the Etchegoin Formation apparently scarcely differs from Recent *M. indentata* and is not referable to the species described by Arnold.

Grant and Gale suggested the possible identity of *Macoma moliniana* Dall (1048) from Coos Bay, Oregon, with *M. indentata*. The species described by Dall has a strong posterior flexure but the shape of the pallial sinus is quite different from that on the corresponding valve of *M. indentata*. Weaver (1049) compared *M. moliniana* with *M. nasuta* and cited it as occurring in beds of Oligocene age.

Macoma indentata has been reported from beds of Pliocene age in the Los Angeles basin, in San Joaquin Valley, in the Santa Maria district, as well as at Coos Bay, Oregon, and elsewhere.

Simonova (1050) reported *M. indentata* as occurring in late Tertiary beds on Sakhalin Island but we have not seen specimens from there.

Macoma (Rexithaerus) indentata tenuirostris Dall

Plate 41, Figure 15; Plate 50, Figure 7

Plate 52, Figure 2

Macoma (indentata Carpenter, var.?) *tenuirostris* Dall, Proc. U. S. Nat. Mus., Vol. 23, No. 1210, p. 324, November 14, 1900. P. 309, as "*Macoma (Rexithaerus) indentata* var. *tenuirostris* Dall."

Macoma indentata tenuirostris Dall, Johnson and Snook, Seashore Animals of the Pacific Coast (Macmillan Co.: New York), ed. 1935, p. 451, fig. 443. "Santa Barbara Islands to San Diego (Kelsey)." Recent.

Type specimen. — No. 73469, United States National Museum.

Type locality. — "San Pedro, California." (Dall.)

Range. — Middle Pliocene to Recent. Recent from Santa Barbara, California, to Ensenada, Lower California, Mexico, in 91 to 137 meters (50 to 75 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305A, 331.

Original description. — "This form differs from the typical *indentata* in being more elongated, with a shorter and more pointed posterior end and deeper flexure." (Dall, p. 309.)

"For the rostrate form, pending the acquisition of more and fresh material, I would propose the varietal name of *tenuirostris*. It measures: lon. 55, alt. 33, and diam. 16 mm. The nearest specimen of the typical form measures respectively 44, 31 and 12 mm. The beaks are 25 mm behind the anterior end and in *tenuirostris* 33 mm behind it. The left valve is notably flatter than the other in the type [*M. indentata*], while in the only pair we have of the variety the valves, though flexuous, hardly differ in degree of convexity." (Dall, p. 324.)

Remarks. — *Macoma indentata tenuirostris* is here reported from the San Diego Formation for the first time. A right valve (the posterior end incomplete), is 40 mm long and 28 mm high. Faustman (1951) illustrated a fossil that is probably this subspecies, from the Rio Dell Formation of Pliocene age in Humboldt Co., California. It also has been reported from beds of late Pleistocene age in the Newport Bay (1952) area in southern California.

Some authors (1953) have considered this subspecies to be without taxonomic significance. We have examined six Recent right valves from San Diego in the Henry Hemphill collection of the California Academy of Sciences. The largest one is 55 mm long and 33.5 mm high, the beak is 31 mm from the anterior end. The posterior end is rostrate and pointed. These differ from typical *M. indentata* in the shell characters enumerated by Dall.

Fossil specimens in the present collection, 25 to 30 mm in length appear to be comparatively longer in outline than do adult forms.

Macoma copelandi Wiedey (Trans. San Diego Soc. Nat. Hist., Vol. 5, No. 10, p. 149, pl. 19, fig. 2, March 31, 1928) described from the Temblor Formation in San Luis Obispo Co., is less attenuated posteriorly and more inflated anteriorly in comparison to *M. i. tenuirostris* Dall.

GENUS *FLORIMETIS* OLSSON AND HARBISON

Florimetis Olsson and Harbison, Acad. Nat. Sci. Phil-

adelphia, Mon. 8, p. 129, November 6, 1953. "Type herewith designated: *Tellina intastriata* Say. Recent, Florida." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 410, 1961. Type as designated by Olsson and Harbison.

Type species (by original designation, Olsson and Harbison, 1953): — *Tellina intastriata* Say [Jour. Acad. Nat. Sci. Philadelphia, Vol. 5, Pt. 2, p. 218, February, 1826. "Coast of East Florida." Illustrated by Olsson and Harbison, 1953, p. 129, pl. 15, figs. 1, 1a, 1b. Key West, Florida, Recent. — Afshar, Geol. Soc. Amer., Mem. 119, p. 92, pl. 39, figs. 1-5, 1969 (as *Apolymetis (Florimetis) intastriata*.) Florida.]

Range.—Late Oligocene to Recent. Recent in warm temperate and tropical waters, from the littoral zone to 46 meters (25 fathoms).

Original description. — Shell broadly subovate, inequivalve with a wide, depressed, or wing-like posterior area, which in the right valve is set-off by an angled keel extending from the beak to the posterior extremity. Both valves are strongly convex along the anterior umbonal slope, the right valve being impressed just behind it or across the middle. Interior shows the adductor scars plainly marked in the adult, the anterior scar being narrow, elongated or lucinoid, with the pallial line attached to its hinder end, posterior scar rounded and placed quite low. Pallial sinus deep, reaching nearly to the anterior adductor scar and confluent below with the pallial line by more than half its length. Hinge with small cardinal teeth, the left anterior and the right posterior being bifid, no laterals. Ligament strong, external, the resilium portion forming the larger part of the scar. Exterior white or colorless, the surface sculpture smoothish or of finely crowded growth lines, much heavier on the posterior wings. (Olsson and Harbison.)

Remarks. — The species in the present paper referred to the genus *Florimetis* has been cited in earlier literature under the generic names *Metis* (1954), *Polymetis* (1955), and *Apolymetis* Salisbury (1956).

Olsson and Harbison, and later Keen, pointed out that the west American species referred to *Apolymetis* are quite different from the East Indian species, *Tellina meyeri*, the type species of that genus. The outline of the type species of *Florimetis* is subquadrate, the posterior flexure very well developed, the anterior end is rather inflated and the posterior portion is sculptured with rather coarse concentric lines of growth. This is quite different from the oval outline and fine, regular concentric lines of growth on *Tellina meyeri*.

Olsson and Harbison recognized *Florimetis* as a subgenus of *Hemimetis* Thiele (1957), and Keen placed it as a subgenus of *Psammotreta* Dall (1958). Olsson, 1961, gave *Florimetis* generic status and we follow this practice, at least until there is general agreement concerning the nomenclature of the supraspecific units of the Tellinidae.

Weaver and Kleinpell recently reported a species under the name of "*Apolymetis cf. A. sespeensis* (Loel and Corey)" (1959) from strata believed to be of Oligocene age. That species was originally described under the genus *Macoma* and the illustration by Weaver and Kleinpell bears a general resemblance to some species of *Macoma*, such as *Macoma constricta* Bruguière (1960). The fossil is not referable to *Florimetis* s. s. Weaver and Kleinpell mentioned that *Poromya teglandae* Weaver, 1942, and *Apol-*

ymetis twinensis Durham are synonymous with *Macoma sespeensis* Loel and Corey, 1932.

"*Metis*" *rostellata* Clark and "*Metis*" *vancouverensis* Clark and Arnold were described from strata assigned an Oligocene age.

Florimetis biangulata Carpenter
Plate 53, Figures 14, 17, 19

T[ellina]. alta Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 258, 1837. "Inhabits coast of California, near Sta. Barbara."

Not *Tellina alta* Conrad, Fossil Shells of the Tertiary Formations of North America (reprint by G. D. Harris, 1893), Vol. 1, no. 4, p. 41 (67), October, 1833.

?*Scrobicularia biangulata* Carpenter, Proc. Zool. Soc. London for 1855, p. 230, February 5, 1856.

Arcopagia medialis Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 8, p. 314, December, 1856 [1857]. "Monterey Co., Cal." "Middle Tertiary." — Conrad, U. S. Pac. Railroad Expl., Vol. 6, Pt. 2, No. 2, p. 70, pl. 2, fig. 6, 1857.

Arcopagia unda Conrad, U. S. Pac. Railroad Expl., Vol. 7, p. 192, pl. 4, figs. 3, 4, 1857. "Shore of Santa Barbara county, California." Miocene.

Metis alta Conrad, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 160, 1903. "Pliocene at Pacific Beach." — Arnold, U. S. G. S., Prof. Paper 47, p. 28, 1906. "San Diego Formation as developed in the type section at Pacific Beach, north of San Diego. . .", Pliocene. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 172, 181 1912. "San Diego-Purisima." — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 151, 1919. "San Diego" Pliocene. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 169, pl. 57, fig. 3, 1924. Pliocene to Recent. — Hertlein, Stanford Univ. Bull., Ser. 5, No. 8, p. 84, 1929. "San Diego Pliocene."

Apolymetis biangulata Carpenter, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 363, pl. 20, fig. 16 (Barlow Canyon, Pleistocene), 1931. "Pliocene of Pacific Beach, San Diego (Arnold 1903)." — Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 89, pl. 24, fig. 1; pl. 25, fig. 12, 1950. "Miocene (?) to Recent." — Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 72, fig. 38, 1953. "Point Conception, California, to San Quentin, Baja California," Recent. — K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 107, pl. 14, fig. 5, 1958. (Carpenter's original description; type specimen illustrated.)

Florimetis biangulata Carpenter, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 64, pl. 30, figs. a, b, 1968. San Diego, Pleistocene. Also "Pliocene at Pacific Beach."

Type specimen. — No. 61.5.20.117, British Museum (Natural History).

Type locality (of *Scrobicularia biangulata*). — "Hab. Sta. Barbara; legit. T. Nuttall, Esq. Museo suo."

Range. — ? Early Miocene (Vaqueros and Temblor). Late Miocene to Recent. Recent, Point Conception, California, to San Quintín Bay, Lower California, Mexico, from littoral zone to 46 meters (25 fathoms); often along the outer coast in coarse sand and gravel or near boulders.

Occurrence in San Diego Fm. — C.A.S. 12, 114.

L.A.M. 305. U.C.L.A. 312.

Original description of ?*Scrobicularia biangulata*. — ? S. t. suborbiculari, subaequilaterali, convexiscula, striis concentricis vix regularibus, postice undata, angulis duobus subobsoletis; ligamento externo tenuissimo, in sulcos alte impresso, semi-interne sito; ligamento interno fossa trigonali scalena sito, alteri adjacente; dentibus cardinalibus in utraque valve duobus, contiguis, vix radiantibus; cicatricibus muscularibus subovalibus, sinu palii maximo; alba, intus aureo tincta. Long. 1.5, lat. 1.78, alt. .8 poll. (Carpenter.)

Remarks. — A specimen of this species collected by Henry Hemphill in the San Diego Formation is approximately 71 mm long, 55 mm high and the convexity (both valves together), 30.5 mm. Three single valves, the largest one about 60 mm long, were collected near the Mexican boundary by George P. Kanakoff.

This large, suborbicular tellinid attains a length of about 83 mm. It can be readily recognized by the well developed posterior fold, and anterior to this a shallow but pronounced submedian concavity extends from near the umbos to the ventral margin of the right valve. The hinge of each valve has two teeth, the right posterior and the left anterior ones the larger. On a Recent specimen 72.4 mm long the pallial sinus extends forward 52 mm and joins the pallial line 36 mm from the posterior end of the shell.

The longer ligamental area, wider hinge plate, and higher cardinal teeth are features which serve to separate *Florimetis biangulata* from the tropical west American species, *F. cognata* Pilsbry and Vanatta (1061) of which *F. clarki* Durham (1062) is a variety. *Florimetis cognata* often has been recorded in the literature under the name of "*Metis*" *excavata* Sowerby (1063), a species with a wedge-shaped posterior end and described without information as to the locality from which it came. Study of the hinges of *F. biangulata* and *F. cognata* led Durham to doubt the reported occurrences of the former in beds of Miocene age. It also is quite possible that various records of the occurrence of *F. biangulata* in subtropical west American waters may be questionable. It has been recorded in beds of Pliocene age at various localities in the San Joaquin Valley and in southern California but not in the northern part of the state. However, it does occur in beds of Pleistocene age at Tomales Bay, Loc. 563 (CAS), in central California.

Dall (Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1044, 1900) pointed out that a poorly preserved fossil from Santa Barbara Co. described by Conrad in 1857 as *Arcopagia unda*, is probably identical with the present species.

Khomenko (1064) recorded the occurrence of "*Metis alta*" in the late Tertiary of Kamtschatka but the identity of that form with the present species needs confirmation.

Keen (1065) recently stated that two species (1066) described from the Orient in 1855, *Tellina turgida* Deshayes from "Catbalonga, Philippines," and *Tellina obesa* Deshayes from "China Seas," are probably identical with *Scrobicularia biangulata* Carpenter. She gave reasons for preferring usage of the name *Tellina obesa* rather than *T. turgida* if the Internatl. Comm. on Zool. Nomencl. should rule that the species name proposed by Carpenter should be replaced by one of the earlier names of Deshayes.

FAMILY SEMELIDAE STOLICZKA (1067)

Description.—Shell round or ovate in outline, valves gently convex, the posterior end with an obscure fold; resilium internal, resilifer elongate and nearly parallel to the hinge; hinge with two cardinal teeth, and usually with laterals; pallial sinus long and wide. Eocene to Recent.

Remarks. — The internal resilium serves to separate this family from the Tellinidae in which the resilium is external.

Yonge (1068) discussed the structure and adaptation of members of this family, most of which live on sandy bottoms and have long siphons.

Key to genera of Semelidae

- A. Pallial sinus free from the pallial line *Semele*
- B. Pallial sinus confluent with the pallial line *Cumingia*

GENUS SEMELE SCHUMACHER

Semele Schumacher, Eassai Nouv. Syst. Vers. Test., p. 165, pl. 18, fig. 2, 1817. Sole species, *Tellina reticulata* Spengler. — Lamy, Jour. de Conchyl., Vol. 61, No. 3, p. 314, 1914. "dont le type est *S. reticulata* Sow. = *S. proficua* Pult." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 375, 1931. "Type (by monotypy), *Tellina reticulata* Spengler = *Tellina proficua* Pulteney; Caribbean; Recent."

Type species (by monotypy and by original designation). — *Tellina reticulata* Spengler [Skript. Nat. Selsk., Vol. 4, Heft 2, p. 115, 1798.] [= *Tellina proficua* Pulteney, Catalogues of the Birds, Shells, . . . Plants, . . . Doreshire, p. 29, pl. 5, fig. 4 (as *T. reticulata*), 1799. "On the sands at the North shore, Poole, and at Weymouth." [Locality erroneous. This species lives along the coast of southeastern United States and in the West Indies.] Illustrated (hinge) by Lamy, 1914, p. 315, also illustrated by L. Perry, Bull. Amer. Paleo., Vol. 26, No. 95, p. 77, pl. 16, fig. 103, 1940. Southwest Florida in 3 to 6 fathoms. Concerning *T. proficua* see Bowden and Heppell (Jour. Conch. Vol. 26, No. 5, pp. 324, 328, 1969)].

Range. — Eocene to Recent. Recent chiefly in warm temperate and tropical waters. From the littoral zone to about 112 meters (61 fathoms), perhaps deeper.

Description. — Shell oval or suborbicular, slightly inequivalve, usually more or less rostrate posteriorly. Umbones subcentral, low, proximate, prosogyrate. Ligament short, external; resilium strong, internal. Hinge armature of 2 cardinals and 2 laterals in each valve, the laterals of the right valve usually stronger. Adductor impressions large, semielliptical. Pallial sinus profound. (Gardner, J., U. S. G. S., Prof. Paper 199, p. 100, 1948.)

Remarks. — Five species of *Semele* have been reported from the Tertiary of California. Another one is here recorded for the first time from the San Diego Formation. Over thirty species now live in tropical and subtropical waters of the western Americas.

Lamy (1069) published a summary of the species of this genus represented in the collections of the Natural History Museum in Paris. Dall (1070) published notes on the west American species of *Semele* and more recently Hertlein and Strong (1071) discussed and illustrated a number of species from this region, as have Keen (1072), and Olsson (1073).

Key to Species of *Semele*

- A. Concentric rugae rounded, sometimes nearly obsolete; a small, narrow, depressed lunular area present *rubropicta*
- B. Concentric rugae flat-topped, regular; depressed lunular area slight or lacking *ashleyi*

Semele ashleyi n. sp.

Plate 48, Figures 3, 4, 6, 9, 10

Semele cf. *S. rubropicta* Dall, Woodring, in Woodring and Bramlette, U. S. G. S., Prof. Paper 222, p. 88, pl. 14, fig. 12, 1950. "Foxen mudstone at the Waldorf asphalt mine, in the Cebada member of the Careaga sandstone at Fugler Point and locality 177, and may be present in diatomaceous strata of the Sisquoc formation." Santa Maria district, southern California.

Type specimens. — Holotype and paratypes in Los Angeles County Museum, Department of Invertebrate Paleontology.

Type locality. — Loc. 305C (LAM), exposure at hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U. S. G. S. topog. map, San Ysidro quad., rev. 1953).

Range. — Middle Pliocene.

Occurrence in San Diego Fm. — L.A.M. 305, 305C, 318.

Description. — Shell elongately ovate, the posterior end shorter, the posterior ventral margin faintly truncated, the general outline and shell characters similar to those of *Semele rubropicta*. Sculpture consists of rather coarse, slightly flattened, concentric ridges which increase in width with growth of the shell, these are separated by incised grooves which are about one third to one fourth the width of the ridges; both ridges and grooves are crossed by fine, shallow, irregularly spaced radial lines, most readily observable on slightly eroded specimens; hinge of right valve with an anterior cardinal, a central cardinal followed by ligamental area, an anterior and a posterior lateral are present, left valve with a thick anterior cardinal, followed by a thin central cardinal and a resiliar pit, an anterior and a posterior lateral are present; pallial sinus broad, slightly ascending, the end broadly rounded and faintly ellipsoid at the distal portion. Dimensions of holotype; length 40.5 mm, height 37 mm convexity (both valves together) 23.6 mm, pallial sinus extends anteriorly 28.5 mm from the posterior end of the valve.

Remarks. — The holotype, single valves, and several fragments of this new species, in the collections of the Los Angeles County Museum from near the Mexican boundary, were available for study.

This species appears to be identical with the one

illustrated by Woodring (1950) as "*Semele* cf. *S. rubropicta* Dall" from strata of Pliocene age in the Santa Maria district in Santa Barbara Co., California.

The concentric ridges of *Semele ashleyi* n. sp. are coarser and are separated by wider and more deeply incised grooves than those on *S. rubropicta*. Also the lunular area beneath the beaks of *S. ashleyi* is only slightly depressed whereas on *S. rubropicta* there is a small but well developed, narrow, depressed lunular area (see plate 48, figure 7).

One lot of Recent specimens, 3 paired valves, the largest 30.5 mm long, and several small single valves of a *Semele* in the collections of the California Academy of Sciences collected by Henry Hemphill from roots of kelp in deep water off San Diego, California, closely resemble the fossil form here described from the San Diego Formation. The chief differences noticed in comparison of this lot of Recent specimens with specimens of the new species of comparative size, are that the ribbing on the umbos of the Recent shells becomes coarser at an earlier stage of growth and the depressed lunular area is comparatively larger than it is on *S. rubropicta*.

A small right valve from Loc. 305 (LAM) illustrated on Plate 48, Figures 4 and 8, is probably a juvenile form of *S. ashleyi* n. sp.

This new species is named for Dr. George H. Ashley, author of an important paper (1895) dealing with the Pliocene of central California.

Semele rubropicta Dall
Plate 48, Figures 1, 2, 7, 11

Semele rubropicta Dall, Amer. Jour. Conch., Vol. 7, Pt. 2, p. 144, pl. 14, fig. 10, November 2, 1971. "Habitat. Beach at Soquel, Monterey Bay, two or three valves, Dall; San Pedro, Cooper; Neah Bay, one worn valve, Swan." — Arnold, U. S. G. S., Bull. 396, pp. 31, 156, pl. 25, fig. 3, 1909. "Upper Etehegoin formation." — I. S. Oldroyd, Publ. Puget Sound Biol. Sta. Vol. 4, p. 56, pl. 22, fig. 10, 1924. [Copy of original figure.] Off San Juan and Lopez Islands, Washington, also other locs. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 180, pl. 43, fig. 10, 1924. [Copy of original figure.] "Forrester Island, Alaska, to Tia Juana, Lower California." — Dall, Proc. U. S. Nat. Mus., Vol. 66, Art. 17, p. 26, pl. 18, figs. 1, 2, 1925. "Beach at Soquel, Monterey Bay, Calif." — Johnson and Snook, Seashore Anim. Pac Coast (Macmillan Co.: New York), ed. 1935, p. 453, fig. 448. Alaska to Lower California. — Stewart, in Woodring, Stewart and Richards, U. S. G. S., Prof. Paper 195, p. 33, list opp. p. 38 and list opp. p. 78, pl. 11, fig. 18, 1940 [1941] (as *Semele* cf. *S. rubropicta*). — Abbott, Amer. Seashells (D. Van Nostrand Co.: New York, London, Toronto,) p. 435, pl. 29, fig. W., 1954. "Alaska to Mexico."

Type specimen. — No. 101960, United States National Museum.

Type locality. — "Beach at Soquel, Monterey Bay, Calif." (Dall, 1925.)

Range. — Early Pliocene (Jacalitos) to Recent. Recent from Forrester Island, Alaska, to Tijuana, Lower California, Mexico, in 37 to 91 meters (20 to 50 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305, 305C, 318.

Original description. — Shell usually pure white and brilliantly polished within, but occasionally with a faint yellowish or pinkish flush when very deeply colored externally. Inner margin, except on the hinge-line, always pure white. Outside, covered with a thin yellowish green or olive, epidermis usually wanting, color yellowish white, with rose-pink and pure white rays, color stronger on the lines of growth. Sculpture consisting of incised lines radiating from the umbones where they become obsolete; crossed by rounded, smooth, concentric ridges rather sharply defined by concentric grooves. These ridges are usually regular but sometimes bifurcating. In perfect specimens the radiating lines and grooves are so sharp that their intersections appear as if punctured. Ligament pit deep and excavated, cardinal and lateral teeth moderate. Anterior end much produced, rounded, margin rounded below, posterior end very short, almost truncated; shell rather inflated. Lunule deeply impressed, narrow, lanceolate, short. General form subquadrate. Umbones inconspicuous, usually tinged with yellow. Hinge-line below the lunule with a purple spot. Interior marked with extremely faint radiating lines. Posterior portion of the inferior margin produced. Shell thick and solid. Alt. 1.35 in. Lon. 1.55 in. Diam. .7 in. Lunule .24 in. (Dall.)

Remarks. — A well preserved specimen from Loc. 305C, (L.A.M.), is 42.8 mm long, 36 mm high, convexity (both valves together) 22 mm and a right valve from the same locality, the ventral portion incomplete, is 47.5 mm long. One fairly well preserved right valve, 45.6 mm long and 39 mm high, is present in the collection from Loc. 318 (LAM). A number of fragments and small valves also are present at Loc. 305 (LAM) near the Mexican boundary. The sculpture on these fossils varies as it does on Recent specimens.

The largest Recent specimen in the collections of the California Academy of Sciences, from Puget Sound, is 50.5 mm long, 41.8 mm high, convexity (both valves together), 24.8 mm, the broadly rounded pallial sinus extends anteriorly 31.5 mm from the posterior end of the valves.

Sculpture in this species varies from specimen to specimen and sometimes varies on the two valves of the same specimen. The concentric sculpture may be very fine or fairly coarse and fairly regular to irregularly spaced. Some Recent shells bear deep concentric grooves at intervals of from 3 mm to 10 mm on some specimens in the collections of the California Academy of Sciences, the umbonal area is nearly smooth. The shells of this species in the northern portion of their range are relatively smooth whereas those in more southern waters tend to develop concentric rugae.

Semele fausta Nomland (Univ. Calif. Publ. Bull. Dept. Geol., Vol. 10, No. 4, p. 233, pl. 9, figs. 3, 3a, 3b, April 19, 1917) described from Etehegoin beds of Pliocene age in middle California, differs from *S. rubropicta* in the more posteriorly situated beaks and in other details.

GENUS CUMINGIA SOWERBY

Cumingia Sowerby, Proc. Zool. Soc. London for 1833, p.

34, May 17, 1833. Four species cited including *Cumingia lamellosa* Sowerby. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 998, 1900. "Type *C. mutica* Sby." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 370, 1961. Type as designated by Gray, 1847.

Type species (by subsequent designation, Gray, Proc. Zool. Soc. London for 1847, p. 187). — "*C. lamellosa*" [*Cumingia lamellosa* Sowerby, 1833, p. 34. "Hab. prope littora Oceani Pacifici." "Found at Payta in hard clay at low water; and at Panama in deep water." — Sowerby, Reeve's Conch. Icon., Vol. 19, *Cumingia*, species 5, pl. 1, fig. 5, 1873. "Hab. Chili." — Olsson, 1961, p. 371, pl. 66, figs. 10, 10a; pl. 67, figs. 3, 3a, 1961. Gulf of California to northern Peru].

Range. — Miocene to Recent. Recent in the western Americas from Crescent City, California, to Chile, nestling in holes bored by mollusks or in crevices in rocks, piling, gravel, etc., from the intertidal zone to 46 meters (25 fathoms). Also Japan and western Atlantic, from the littoral zone to 91 meters (50 fathoms).

Description. — Shell often distorted but normally equivalve, inequilateral, anteriorly rounded, posteriorly subtruncated and slightly gaping; lunule small and escutcheon larger in left valve; sculpture principally concentric, formed by elevated ridges, their interspaces minutely striated or sagginated; ligament partially external and internal, the external ligament small and overlies a large posteriorly directed chondrophore or resilifer developed equally in both valves; anterior side of resilifer bordered by a small cardinal tooth and socket; right valve with two strong lateral teeth bordered above by sockets into which fit the thickened margins of the other valve; pallial sinus large, confluent below with the pallial line. (Adapted from H. and A. Adams, Gen. Rec. Moll., Vol. 2, p. 412, 1858, and Olsson and Harbison, Acad. Nat. Sci., Philadelphia, Monogr. No. 8, p. 135, 1953.)

Remarks. — The genus *Cumingia* was recorded doubtfully from the San Diego Formation by Dall and the present record is based upon fragments retaining portions of the hinge. This genus has been reported from Pliocene to Recent in western North America but in eastern North America it is known to occur in beds of Miocene age. A species was described as "*Cumingia? antiquata*" (1074) by Philippi from beds of Tertiary age in Chile but an inspection of the illustration convinces us that the generic assignment is doubtful. Von Ihering (1075) stated that *Cumingia* does not occur in beds of Tertiary age in Patagonia.

Cumingia? keittensis Harris was described from strata of Eocene age in Alabama but the generic assignment remains open to question.

The genus *Cumingia* is represented in strata of Pliocene and Pleistocene age in California by but one species which also lives in adjacent waters. One species, *C. densilineata* Dall, was described from beds of Pleistocene age at San Quintín, Lower California. Several Recent species have been described from more southern waters but it is apparent that there are too many names for the species represented. However, at least three species live in the region between California and Chile.

Dall (1900, p. 999) pointed out that on both the Pacific and Atlantic coasts of the United States, the species in the northern part of their ranges are larger, the

sculpture is more regular and less sparse, whereas in the southern part of their ranges, the shells diminish in average size and concentric lamellae become relatively more prominent. The shell of *Cumingia* is variable in shape and sculpture as a result of the animal's habit of nestling in holes and crevices.

The soft parts of *Cumingia* were described by Deshayes (1076), and Grave (1077) discussed the natural history of *C. tellinoides*.

The Recent species of *Cumingia* in the Natural History Museum in Paris were discussed by Lamy (1078).

Stoliczka, 1871, placed *Cumingia* in a subfamily cuminginae.

Cumingia cf. *C. californica* Conrad

The following references refer to typical *Cumingia californica*. *C.[um]ingia californica* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 234, pl. 17, fig. 12, 1837. — Dall, Proc. U. S. Nat. Mus., Vol. 1, p. 11, 1878. "Later Tertiary" of San Diego. Also Recent. — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 1001, 1900. "Pliocene of San Diego?; Hemphill." — Arnold, Smithsonian Misc. Coll. (Quart. Issue), Vol. 50, Pt. 4, p. 445, pl. 56, fig. 5, 1907. "Fugler Point asphalt mine, near Gary," California, Pliocene. Also Recent. — Arnold, U. S. G. S., Bull. 322, pp. 58, 148, pl. 23, fig. 5, 1907 (1908). Some records as in preceding reference. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 171, 181, 1912. "San Diego-Purísima," Pliocene. — Lamy, Jour. de Conchyl., Vol. 61, No. 3, 1914. "San Diego," Recent. — Abbott, American Seashells. (Van Nostrand Co.; New York), p. 436, pl. 31, fig. V, 1954. "Crescent City, California, to Chile."

Type specimen. — Location of the type specimen unknown to the present authors.

Type locality. — "Inhabits with the above; rare." [The above is *Sphenia californica* from "Inhabits salt marshes, near Sta. Barbara; rare."]

Range. — Pliocene (Jacalitos) to Recent. Recent from Crescent City to San Martin Island, Lower California, Mexico, from the intertidal zone to 46 meters (25 fathoms), in holes bored by mollusks and in crevices in rocks, piling, and in gravel.

Occurrence in San Diego Fm. — L.A.M. 305.

Original description. — Shell triangular, convex, thick, with numerous irregular lamellar concentric striae; posterior side compressed, cuneiform; beaks central, rather prominent; lateral teeth prominent. Length, one inch and one-fourth. (Conrad.)

Remarks. — The present record of *Cumingia californica* in the San Diego Formation is based upon three fragments, of which one left valve retains a part of the hinge with most of the chondrophore and a small tooth anterior to it. An occurrence of *Cumingia californica* in strata of Pliocene age at San Diego would not be out of place because it has been reported from beds of Pliocene age in San Joaquin Valley and in the Cebada Member of the Careaga Formation in the Santa Maria district along with other species which likewise occur in the San Diego beds.

Strong (1079) pointed out that *Cumingia californica*

at times has been confused with more southern species, especially *C. lamellosa* Sowerby (1080). The latter species is only about a fourth the size of *C. californica* and is more triangular in outline. *Cumingia lamellosa* Sowerby is a different species from the one described as *Thyella lamellosa* H. Adams (1081) (= *C. elegans* Sowerby) from the East Indian Archipelago and Australia, a species placed at times by some authors in the genus *Cumingia*.

A large specimen of *Cumingia californica* in the Academy's collection, taken at San Diego by Henry Hemphill, is 30.1 mm long, 22.8 mm high, the convexity (both valves together) 11.8 mm, the pallial sinus extends forward 20 mm from the posterior end of the valve and joins the pallial line after a short bend posteriorly. The hinge of the right valve has a lateral tooth on each side and the left valve has a small cardinal tooth in front of the ligamental pit. A weak lateral or extension of the margin on each side fits into sockets in the opposite valve.

The shell of this species is often distorted because of the animal's habit of nestling in crevices in rocks and other objects.

FAMILY DONACIDAE FLEMING

The shell is generally transversely trigonal to cuneiform, equivalve, solid in texture, with entire or crenulated and usually closed margins. The surface is smooth or with fine radial lineation or riblets. The ligament is external, short, usually opisthodontic, and attached to and along a nymphal plate. Pallial line distinct, placed a short space above the margin, its sinus short or of medium length, generally directed horizontally, its end well rounded. The adductor scars are subequal in size and often deeply impressed. Substance of the shell is usually coarse; porcellaneous, white externally or grading into violet or purple, the same coloration in the interior. (Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 336, 1961.) Late Cretaceous to Recent.

Remarks. — An account of the structure and adaptation of the shells of this family of mollusks was published by Yonge (1082) and Chavan (1083) discussed the systematic position of members of this family. Many of the Recent tropical west American species were discussed by Hertlein and Strong (1084), by Keen (1085), and by Olsson (1086).

GENUS DONAX LINNAEUS

Donax Linnaeus, Syst. Nat., ed. 10, p. 682, 1758. *Donax rugosa* Linnaeus included in original list of species. — Römer, Syst. Conchyl. - Cab. von Martini und Chemnitz, Bd. 10, Abt. 3, p. 4, 1871.—Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 378, 1931. Type (as designated by Herrmannsen): "*Donax rugosus*" Linnaeus.—Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 77, 1952. Type (as designated by Schumacher): *Donax rugosus* Linnaeus.

Type species (designated by Schumacher, Essai

Nouv. Syst. Vers Test., p. 144, 1817.) — "*Donax rugosa* Lin." Ref. to "Pl. XIII. fig. 4. Chemn. 6, pag. 254. Tab. 25. fig. 250." This species also was designated as the type species of *Donax* (of Lamarck) by Schmidt, Versuch Conchyl. - Samml., pp. 55, 176, 1818; also designated as type by Herrmannsen, Indic. Gen. Malac., Vol. 1, p. 404, 1847, and by Gray, Proc. Zool. Soc. London for 1847, p. 187. [*Donax rugosa* Linnaeus, Syst. Nat., ed. 10, p. 682, 1758. "Habitat in O. meridionali." Ref. to Gualtieri, Test., pl. 89, fig. D. Illustrated by Reeve, Conch. Icon., Vol. 8, *Donax*, sp. 9, pl. 2, figs. 9a, 9b, 9c, 1854. "Hab. Gold Coast, West Africa."—Nicklés, Moll. Test. Mar. Cote Occid. d'Afrique. Man. Ouest - Africains, Vol. 2, p. 211, fig. 405 (p. 212), 1950. See also Dodge, 1952, p. 80.]

Range. — Eocene to Recent. Recent, world wide in warm temperate and tropical waters, from between tides to about 82 meters (45 fathoms), on sand.

Description. — Shell moderately small, elongate-trigonal to subcylindrical in outline, closed; beaks prosogyrous, posterior to subcentral; anterior end produced and rounded, posterior end short, sometimes truncated; sculpture consists of fine radial riblets, sometimes punctate; ligament external; hinge usually with two cardinals in each valve, one commonly bifid, laterals variable; pallial sinus deep, horizontal, partly confluent with pallial line ventrally; margins usually crenulated.

Remarks.—*Donax* apparently is not known to occur earlier than Eocene time. *Notodonax* Ferruglio (1087) was described from beds of late Cretaceous age in Argentina and *Protodonax* Vokes (1088) was described from strata of late Cretaceous age in Wyoming.

At the present time, about one hundred species of *Donax* live in very shallow, warm temperate and tropical marine waters. The northern range of this genus along the coast of California is about 35° 10' 00" N.

[*Donax californicus* Conrad]

D[onax]. californica Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 254, pl. 19, fig. 21, 1837.—Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, p. 968, December, 1900. "Pliocene of San Diego, California, Well."

Donax flexuosus Gould, Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 238, 1888. "Pl. — San Diego Well."

Not *Donax flexuosus* Gould, 1853 = *D. striata* Linnaeus, 1767. See Dall, 1900, p. 968.

Type specimen. — Twelve syntypes, No. 61.5.20.91, British Museum (Natural History) (A. M. Keen, Veliger, Vol. 8, No. 3, p. 170, 1966.)

Type locality. — "Inhabits the coast of California in sand, near Sta. Barbara."

Range. — Pleistocene to Recent. Recent, Goleta, California, to Magdalena Bay, Lower California, Mexico. "Found in sand or sandy mud of bays, lagoons and estuaries and other localities not exposed to the pounding surf." (Fitch).

Occurrence in San Diego Fm. — San Diego well (Cooper; Dall).

Remarks. — This species was recorded by both Cooper and Dall as occurring among the fossils from the San

Diego well. We have not seen specimens of it in any collections from the San Diego Formation. It occurs commonly in Pleistocene beds in southern California and northern Lower California. It has not been recorded from strata of Pliocene age, so far as we know, by any modern author.

The shell of *Donax californicus* differs from that of *D. gracilis* Hanley (1089), an inhabitant of tropical and subtropical west American waters, in that it is less elongated and the posterior dorsal margin slopes more steeply ventrally.

Recent specimens of *Donax californicus* Conrad were illustrated by Hertlein and Strong (1949, pl. 1, figs. 2, 5) and by Fitch (1090).

SUBGENUS *SERRULA* CHEMNITZ

Serrula Chemnitz, Mörch, Cat. Conchyl. Yoldi, Pt. 2, p. 18, 1853. Several species cited including *Donax trunculus* Linnaeus.—Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 379, 1931. "Type (by subsequent designation, Dall, 1900), *D. trunculus* Linnaeus."

Type species (designated by von Martens, Zool. Rec., Vol. 7, Moll., p. 172, 1870). — "Type *trunculus*, L." [Illustrated by Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 9 (Pelecypoda, Fasc. 22), p. 454, pl. 68, figs. 1, 2, 3, 4, 1893. European seas. For a discussion of this species see Dodge, Bull. Amer. Mus. Nat. Hist. Vol. 100, Art. 1, pp. 80-81, 1952.]

Range. — Pliocene to Recent.

Description. — Shell oval-triangular, cuneiform, gibbous in front; margins denticulated within; hinge with oblong cartilage fissure. (Tryon, 1884.)

Remarks. — The subgeneric assignment of some of the west American Cenozoic species of *Donax* is not entirely satisfactory. However, the following species from the San Diego Formation appears to be better placed in *Serrula* than in any other supraspecific group.

Donax (Serrula) gouldii Dall

Plate 48, Figures 16, 19; Plate 57, Figure 8

Donax obesus Gould, Proc. Boston Soc. Nat. Hist., Vol. 4, p. 90, November, 1851. — Gould, Boston Jour. Nat. Hist., Vol. 6, p. 394, pl. 15, fig. 9, 1853. "Inhabits San Diego."

Donax obesus Philippi, Zeitschr. f. Malakozool., Jahrg. 8, No. 5, p. 75, 1851. "Patria: California ex auct. mercatoris, a quo emi."

Not *Donax obesus* d'Orbigny, Voy. Amér. Mérid., Vol. 5, Moll., p. 541, pl. 81, fig. 28, 30, 1846. "Elle a été pêchée à Payta (Pérou) par M. Fontaine."

Donax gouldii Dall, U. S. Nat. Mus., Bull. 112, p. 49, February 24, 1921. "Santa Barbara, California, to Acapulco." Recent. [New name for *Donax obesus* Gould 1851, not *Donax obesus* d'Orbigny, 1846.] — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 183, pl. 49, figs. 8, 9, 1924. "Range. Santa Barbara, California, to Acapulco, Mexico." (On expl. to pl. 49, as *Donax gouldii*.) — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 380, pl. 13, fig.

12, 1931. Pleistocene to Recent.

Donax gouldii Dall, Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 84, fig. 50, 1953. "Range: Pismo Beach, California, to Cape San Lucas, Baja, California."

Type specimen. — Location of type specimen unknown to the present authors.

Type locality. — "San Diego" [California.]

Range. — Middle Pliocene to Recent. Recent from San Luis Obispo, California, to Todos Santos Bay, Lower California, in intertidal zone, on sandy beaches.

Occurrence in San Diego Fm. — L.A.M. 319. U.C.L.A. 294, 311.

Original description (of *Donax obesus* Gould). — T. parva, solida, ovato-cuneata, ventricosa, nitida, radiatim leviter striata, coloribus albidis et fulvidis omnino vel radiatim picta et plerumque zonis violaceis ornata; angulo postero-dorsali rectangulari; facie posteriori cordiformi, subtriangulari; latere antico angustato, citò rotundato; margine ventrali denticulato, posticè coarctato: intus alba, vel flavescens, violaceo nuberulata, ad marginem dorsalem fuscata. Long. 9/10, alt. 6/10; lat. 4/10 poll. (Gould.)

Remarks. — Ten single valves of *Donax gouldii* are present in the collections of the University of California at Los Angeles from near the Mexican boundary. The largest, a left valve, is 19.4 mm in length. Three valves in fairly good state of preservation, the largest one about 20 mm long, and three fragments are present in the collection of the Los Angeles Museum from Loc. 319 (LAM) near the Mexican boundary. The present specimens are comparable to Recent valves of similar size. A large Recent specimen collected by Henry Hemphill at San Diego is 24.6 mm long, 15.3 mm high, convexity (both valves together) 11 mm.

This species is represented in the collections from the San Diego Formation by a comparatively small number of valves. Fitch, 1953, mentioned that at times, billions of living individuals of this species form a solid pavement several layers deep in the sandy beaches in southern California.

Coe (1091) discussed the ecology of *Donax gouldii* and more recently Pohlo (Veliger, Vol. 9, No. 3, pp. 330-337, figs. 1-5, 1967) discussed aspects of the biology of this species.

FAMILY GARIDAE STOLICZKA

The shell is telliniform, donaciform, or soleniform, usually equivalve and if unequal, the right valve is the larger and more convex, usually with a gap at the posterior end. The surface is often highly colored in which shades of red, pink, and purple predominate, spread uniformly or in a streaked, maculated, or rayed pattern; The hinge has one or two, bifid or grooved cardinal teeth; there are no laterals. The ligament is external, large, lies entirely posterior of the beaks and is attached to a large, nymphaal plate which rises prominently above the hinge margin. The adductor scars are distinct, placed rather high dorsally and connected by a pallial line bearing a deep sinus. The periostracum is usually coarse and dark in color in some groups, thin and inconspicuous in

others. (Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 347, 1961, for Family Sanguinolariidae.) Cretaceous to Recent.

Remarks. — The shells of this family resemble those of the Tellinidae but the posterior end is usually less twisted and the valves more gaping, the hinge plate is broader as are the nymphs back of the beaks and the valves are covered with a thicker periostracum.

The species in this family are more numerous in warm waters; about ten or twelve species distributed in five genera have been reported occurring in tropical and subtropical west American waters.

Dall (1093) published a synopsis of the Cenozoic "Psammobiidae" of North America.

Key to Genera of Garidae

- A. Sculpture of posterior area differentiated from that on remainder of shell *Gari* s. s. (1904)
- B. Sculpture on posterior area not differentiated from that on remainder of shell *Gobraeus*

GENUS GOBRAEUS LEACH

Gobraeus Leach, manuscript name in Brown, Recent Conch. Great Britain and Ireland, edit. 2, p. 102, 1844 (as "*Gobraeus vespertinus*, Leach, MSS." in the synonymy of *Psammobia vespertina*, p. 102, pl. 40, fig. 3). — Leach, Synop. Moll. Gt. Britain, p. 265, 1852. Species cited: "*Gobraeus variabilis*" in the synonymy of which are, *Tellina depressa* [refs. to Pennant and Dillwyn], *Tellina variabilis* [refs. to Pulteney and to Donovan], *Solen vespertinus* [refs. to Bruguière, Wood, and others]. From various localities around Great Britain. — K. V. W. Palmer, Geol. Soc. Amer. Mem. 76, p. 111, 1958. "Type species by monotypy *G. variabilis* Leach=*Solen vespertinus* Gmelin, 1791." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 356, 1961. Type species same as cited by Palmer.

Type species (by monotypy; and by subsequent designation by Dall, Proc. Acad. Nat. Sci. Philadelphia, Vol. 50, p. 57, 1898). — "Type *Psammobia vespertina* Lam. European Seas." [= *Solen vespertinus* Gmelin, Linn. Syst. Nat., ed. 13, Vol. 1, Pars VI, p. 3228, 1791. "Habitat in mari mediterraneo & Atlantico." Illustrated by Wood, Gen. Conch., p. 135, pl. 33, figs. 2, 3, 1835. Mediterranean, Atlantic, and various localities around Great Britain. Also, Reeve, Conch. Icon., Vol. 10, *Psammobia*, species 17, pl. 10, fig. 17, 1865. "Hab. Mediterranean." See also Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Tom. 2, Fasc. 10 (Pelecypoda, Fasc. 23), p. 485, pl. 71, figs. 1-7, 1895 (as *Psammobia depressa* Pennant, fig. 1 (typical), fig. 2 (var. *livida* Jeffreys), figs. 3, 4 (var. *normalis* Bucquoy, Dautzenberg, and Dollfus), figs. 5, 6, 7

(var. *caerulescens* Réquien).]

Range. — Eocene to Recent. Recent from the intertidal zone to 73 meters (40 fathoms), in sand.

Description. — Shell inflated, more or less truncate behind; concentrically striate or nearly smooth, often with fine radial striae, especially evident on the posterior dorsal region; teeth variable, not more than three in the right valve and two in the left valve; sinus rounded in front, rarely shorter than the vertical of the beaks, and often more or less detached from the pallial line. (Dall.)

Remarks. — The shell of *Gobraeus* differs from that of *Gari* in that the posterior dorsal area lacks any differentiation of sculpture from the remainder of the shell other than a coarsening of the concentric threads. The surface of the shells of this genus are often rayed with lilac and purple tints. The valves gape posteriorly.

In recent years, west American species, such as the one referred to the genus *Gobraeus* in the present paper, have been assigned to the genus *Gari* Schumacher (1095). There have been differences of opinion concerning the identification of the type species of *Gari* as revealed in discussions by Stewart (1096), Dodge (1097), Cox (1098), and others.

Schumacher referred to figures 92 and 93 shown on plate 10 by Chemnitz (Neue Syst. Conchyl. — Cab., 1782) and more recently Lemche and Parker (1199) published an illustration of the specimen shown in Chemnitz's figure 93 which was said to have come from Nicobar.

Recently, the Internat. Comm. on Zool. Nomencl. designated *Gari vulgaris* Schumacher, 1817, as type species of *Gari*, as defined by a lectotype selected by Lemche. This species appears to be identical with *Solen amethystus* Wood, 1815 (1101).

The concentric threads on the type species are offset along a groove or line on the posterior area. This interpretation of the type species of *Gari* results in the relegation of all west American species of this group to the genus *Gobraeus*.

Psammobia Lamarek (1102) has been placed in the synonymy of *Gari* by some authors. Keen recently assigned it subgeneric rank under *Gari*.

Mesozoic (1103) species have been referred to "*Psammobia*". However, according to Gardner (1104) that genus is not known with certainty to occur in the Cretaceous but it was well established by mid-Eocene time. Finlay and Marwick (1105) mentioned that *Gari* first appeared in New Zealand in the Bortonian, late Eocene.

Davies (1106) pointed out that on many species of "*Gari*" of Eocene age, the pallial sinus is rather short and free from the pallial line whereas on typical species the pallial sinus is longer and is confluent with the pallial line.

The genus *Gobraeus* is represented by but one species in the fauna of the San Diego Formation. At the present time three species occur in the waters off California and five species have been recorded occurring in tropical and subtropical west American waters. The west American species of *Gobraeus* usually burrow in sand or sandy mud to a depth of several centimeters. Yonge (1107) discussed the structure and adaptation of British species referred to "*Gari*" and mentioned that they are especially adapted to inhabit substrata of coarse sand or shell and gravel.

Gobraeus edentulus Gabb
Plate 48, Figures 13, 15

?*Siliquaria*. *edentula* Gabb, Geol. Surv. Calif., Palaeo., Vol. 2, p. 53, pl. 15, fig. 11, 1869.

Psammobia edentula Gabb, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 174, 182, 1912. "San Diego-Purisima." Lower Pliocene. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 185, pl. 57, fig. 1, 1924. Pliocene to Recent.

Psammobia (*Gobraeus*) *edentula* Gabb, Dall, Proc. U. S. Nat. Mus., Vol. 66, Art. 17, p. 23, pl. 19, fig. 1, 1925. "San Pedro, Calif.: Recent specimen."

Gari edentula Gabb, Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 281, pl. 13, fig. 3, August 9, 1930. "Horizon, Pliocene; locality, San Fernando." [Lectotype discussed and illustrated.] — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 382, pl. 21, fig. 5 (San Pedro, California, Recent), 1931. Late Miocene to Recent. — Fitch, Calif. State Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 80, fig. 46, 1953. Santa Barbara, California, to San Diego, California, Recent.

Gari (*Psammocola*) *edentula* Gabb, Korobkov, Spravochnik I Metodicheskoe Rukovodstvo po tretichnym Molluskam Plastinchatozhabernye [Lamellibranchiata]. Gostoptehizdat [Publishing house], Leningrad, pl. 16, fig. 2 [copy of figure from Grant and Gale], 1954.

Type specimen. — Lectotype No. 15035, Academy of Natural Sciences of Philadelphia.

Type locality. — "From the Pliocene of San Fernando," California.

Range. — Middle Miocene (Temblor, Loel and Corey), to Recent. Recent from Santa Barbara to San Diego, California, in 6 to 24 meters (3 to 13 fathoms), in the more quiet sheltered waters along the outer coast where this species is believed to burrow to a depth of five or six inches (Fitch).

Occurrence in San Diego Fm. — C.A.S. 1129. L.A.M. 178A, 305, 305A, 319. S.D. 2, 4, 331, 365. U.C.L.A. 294, 312, 2359.

Original description. — Shell moderately large, thin, flattened, elongated sub-elliptical, nearly equilateral; beaks minute, a little posterior to the middle, projecting almost insensibly beyond the cardinal line; cardinal margin sloping slightly and perfectly straight towards the two ends; anterior end convexly and very obliquely subtruncate above, produced and rounded below; posterior end broadly and regularly rounded, a little less prominent below than above the middle; basal margin nearly straight. Surface nearly smooth in the middle, marked by pretty distinct lines of growth towards the ends, especially above. Length from beak to base, 1.3 inch; width, 2.6 inch; beak to anterior end, 1.45 inch. (Gabb.)

Remarks. — Several specimens, fairly well preserved, in the collections from the San Diego Formation, are similar to Recent specimens of *Gobraeus edentula*. The largest specimen, from Loc. 4 (SD) south slope of Mount Soledad is 87 mm long, 42.8 mm high, the convexity (both valves together), 17.3 mm. Recent specimens attain a length of about 125 mm. Many fragments from the San Diego Formation in the collections of the Los Angeles County Museum are referable to this species.

The hinge has two cardinal teeth in each valve, those of the left weaker, especially the posterior one which may be reduced to a lamina. Both teeth slope gently posteriorly, the posterior one the more so. There is variation in the size of the teeth in a series of specimens. In some the left anterior tooth is about half its usual height and is flattened on the distal surface.

The pallial sinus extends forward more than one half the length of the shell. On a Recent specimen 125 mm long the pallial sinus extends forward 70 mm and joins the pallial line at about 63 mm from the posterior end of the shell.

The more elongate and more compressed valves sculptured with fine even concentric threads are features which readily serve to separate the present species from *Gobraeus californicus* Conrad, a well known species which has been reported to range from San Diego, California, to Japan.

A fossil cited as "*Psammobia*, aff. *edentula* (Gabb)", was reported by Clark (1108) from the San Ramon Formation which he considered to be of Oligocene age. The preservation of the fossil is so imperfect that identification of the species is uncertain.

The nomenclature of the present species may be involved with that of the earlier *Tellina fucata* Hinds (1109) which was described from Magdalena Bay, Lower California.

FAMILY SOLECURTIDAE D'ORBIGNY

Shell inequivalve, elongated, gaping at both ends. Ligament external. Hinge with or without diverging teeth. (Translation of d'Orbigny, Voy. dans Amér. Mérid., Vol. 5, Moll., p. 522, 1846). Late Cretaceous to Recent, in temperate and tropical seas.

Remarks. — This family is separated from the Soleinidae chiefly on the basis of anatomical characters. These characters, were given by d'Orbigny as follows: "Animal muni d'un manteau fermé plus ou moins, ayant une ouverture buccale par où sort un pied volumineux comprimé. A la région anale se trouvent deux tubes distincts et séparés, plusieurs muscles à chaque valve."

Ghosh (1110) gave a detailed description of the soft parts of some members of this family.

GENUS TAGELUS GRAY

Siliquaria Schumacher, Essai Nouv. Syst. Vers Test., p. 129, 1817. Species cited, *Siliquaria notata* Schumacher, pl. 7, figs. 2, 3, in synonymy of which are *Solen gibbus* Spengler, *Solen guineensis* Chemnitz, *Solen Tagal*, Adanson.

Not *Siliquaria* Bruguière, Tabl. Encyclop. Méthod. (Vers), Vol. 1, p. XV, 1789. [No species cited.] See also Deshayes, Encyclop. Méthod., Vol. 3, p. 950, 1832. *Tagelus* Gray, Proc. Zool. Soc. London for 1847, p. 189, November, 1847. "*Sol. guineensis*" indicated as type. — Gardner, U.S.G.S., Prof. Paper 199, p. 107, 1948. "Type by original designation: *Solen guineensis* *guineensis* Chemnitz = *Solen gibbus* Spengler." — Olsson Mollusks of the Tropical Eastern Pacific (Paleo. Res.

Inst.: Ithaca, New York), p. 350, 1961. "Type species by original designation: *Solen guineensis* (= *Solen gibbus* Spengler)."

Type species (by original designation). — "*Sol. guineensis*" [= *Solen guineensis* W. Wood, Gen. Conch., p. 129, 1815, "Inhabits the coast of Guinea." Ref. to Chemnitz, Syst. Conch.-Cab., Bd. 11, pl. 198, fig. 1937, 1795. "bey der Guineischen Küste wohnet."—Also illustrated by Reeve, Conch. Icon., Vol. 19, *Solecuretus*, species 21, pl. 4, figs. 21a, 21b, 1874 (as *Solen caribaeus*). "Hab. America."]

Range. — Late Oligocene or early Miocene (1111) to Recent. Recent in warm temperate and tropical waters, intertidal zone to 73 meters (40 fathoms).

Description. — Shell with elongated, solen-like valves but with the beaks near the middle, the length between three and four times the height. The anterior side is generally a little fuller, the posterior side often slightly depressed especially near its dorsal margin. Both ends of the valves are rounded and generally with a wide open gap. Hinge weak with two small cardinal teeth in the right valve and only one in the left; there are no laterals. The ligament is external and attached to a high nymphaal plate. Adductor scars large, placed close to the dorsal margin, and connected across by the pallial line bearing a large open sinus. There is sometimes a slight flexure across the middle of the valves, the surface marked with lines of growth only, white or colored faintly with violet or brown, sometimes rayed. The periostracum is dark brown or straw-colored, generally coarsely wrinkled. (Olsson, 1961.)

Remarks.—Only two species of *Tagelus* have been reported from beds of Tertiary age in California, one of which occurs in the San Diego Formation. Ten Recent species have been described from eastern Pacific waters between Monterey, California, and Puerto Montt, Chile.

Hesse (1112) mentioned that many Recent species of *Tagelus* are confined to brackish or estuarine waters. Other species, however, including many fossils are associated with strictly marine forms.

The anatomy of some of the Recent species was described by Bloomer (1113).

Subtagelus Ghosh (1114), is a synonym of *Mesopleura* Conrad, with the same type species, *Solen divisus* Spengler. Ghosh believed that this group possessed more primitive anatomical characters than *Tagelus* s.s.

Keen (1145) placed the genus *Tagelus* in the family Solecurtidae rather than in the Garidae (Psammobiidae).

SUBGENUS TAGELUS S. S.

Tagelus (Tagelus) californianus Conrad

[*Solecuretus*]. *californianus* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 233, pl. 18, fig. 3, 1837.—Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 296, 1874. "Well at San Diego," "Pliocene."—Dall, Proc. U.S. Nat. Mus., Vol. 1, p. 28, 1878. "well-digging in stratum B²," San Diego.—Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 265, 1888. "Pl.—San Diego well."—Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 85, August, 1889. Dall's record

(1874) cited.—Orcutt, cited by Ellis in Ellis and Lee, U.S.G.S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited.

Tagelus californianus Conrad, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 169, 1903. "Pliocene.—San Diego (Dall)."—I.S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 186, 1924. "Pliocene at San Diego." Also Recent.—Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 384, pl. 21, figs. 2a, 2b, 3 (San Pedro Pleistocene), 1931. Dall's record (1874) cited.—Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) cited.—Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull., No. 90, p. 79, fig. 45, 1953. Various localities cited. Recent. *Tagelus (Tagelus) californianus* Conrad, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 68, pl. 32, fig. a (Pleistocene in San Diego), 1968. "Pliocene in Balboa Park," San Diego.

Type specimen. — Syntype No. 54.3.14.55, British Museum (Natural History) (see A.M. Keen, Veliger, Vol. 8, No. 3, p. 171, 1966).

Type locality.—"Inhabits muddy salt marshes, in the neighbourhood of Sta. Barbara; common."

Range. — Pliocene to Recent. Recent from Monterey, California, to the Gulf of California and south to Corinto, Nicaragua, possibly to Panama (1116). In bays, estuaries and sloughs, on mud flats or in sandy mud, burrowing to a depth of 42 cm (20 inches) (Fitch).

Occurrence in San Diego Fm. — San Diego well (Dall). Balboa Park (Moore). L.A.M. 305A.

Original description. — Shell oblong-oval, rather thin, convex; extremities equally rounded; basal margin slightly contracted in the middle; beaks central; colour white, tinged with yellowish brown, and marked with direct brown lines in the middle of the valve; epidermis straw colour with radiating wrinkles on the posterior slope. Length, 3 and a half inches. (Conrad.)

Remarks. — This species was reported among the fossils from the San Diego well by Dall in 1874. A fragment of the umbonal portion of a left valve, 10 mm long, from Loc. 305 A (LAM), near the Mexican boundary, is here referred to *Tagelus californianus*. The hinge and a small muscle impression near the dorsal margin are comparable to the corresponding characters of Recent specimens of *T. californianus*.

A large Recent specimen in the collection of the California Academy of Sciences collected by Henry Hemphill at San Diego, is 112 mm long, 31.5 mm high, convexity (both valves together) 20 mm, the pallial sinus extends anteriorly 50 mm from the posterior end of the shell. A specimen collected by E. P. Chace (1117) at Puertecitos, in the Gulf of California, is 128 mm long. The ciliary mechanism of the present species was described by Kellogg (1118).

Tagelus californianus often occurs on mud flats in estuaries and sloughs. Orcutt (1119) reported this species at Salton Sea, along with freshwater shells, but specimens of *Tagelus* derived from strata in that area (1120) which we have seen are more nearly referable to *T. affinis longisinuatus* Pilsbry and Lowe.

Tagelus californianus was reported by Reagan (1121) to occur in the Quillayute Formation of Pliocene age in western Washington, but Dall (1112) later examined

the specimen, a fragment, and stated that it was referable to the genus *Tagelus* but he could not identify it specifically.

Tagelus clarki Loel and Corey (1123), described from strata of early Miocene age in California, is shorter and more ovate in outline, the valves are more convex and the posterior dorsal concavity and the umbonal ridge are more pronounced than those of *T. californianus*.

SUPERFAMILY SOLENACEA GRAY (1124)

FAMILY SOLENIDAE GRAY (1125)

Shells usually elongate, sword or razor-shaped, equivalve, usually open and truncated at both ends. Beaks low, terminal or somewhat distant from the anterior umbones, larger in those species having the umbones more distant from the end, the adductor scars large and well marked. Hinge relatively weak with one or two small cardinal teeth, more or less projecting, the ligament external and attached to a short nymph. Surface smooth or sculptured with concentric lines of growth, sometimes with oblique striae or groovings, covered by a coarse brown or straw-colored periostracum. Hinge plate often strengthened or buttressed by a thickened ray. Burrowers in sand. (Olsson, A.A., Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 419, 1961.). Late cretaceous to Recent.

Remarks. — Three genera of this family are represented by fossil forms in the San Diego Formation.

A synopsis of the Solenidae of North America by Dall (1126) appeared in 1899. Recently Habe (1127) published a paper dealing with the Solenidae of Japan. Yonge discussed evolution within the Solenidae (Univ. Calif. Publ. Zool., Vol. 55, No. 9, pp. 421-438, figs. 1-8, 1951).

Key to Genera of Solenidae

- A. Beaks terminal or nearly so
 - a. Left valve with one cardinal tooth. *Solen*
 - aa. Left valve with two cardinal teeth *Ensis*
- B. Beaks subcentral or nearly so *Siliqua*

GENUS SOLEN LINNAEUS

Solen Linnaeus, Syst. Nat., ed. 10, p. 672, 1758. *Solen vagina* included in list of species.—Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 385, 1931. Type (designated by Children): *Solen vagina* Linnaeus.—Eames, Philos. Trans. Roy. Soc. London, Ser. B, Biol. Sci., No. 627, Vol. 235, p. 432, 1951. "Type species. *Solen vagina* Linné, Recent = *S. brevis* Gray; Children, 1822."—Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York),

p. 420, 1961. "Type species by subsequent designation, Lamarck, 1799 or by Schumacher, 1817, *Solen vagina* Linné."

Type species (designated by Schumacher, Essai Nou. Syst. Test., p. 124, pl. 6, fig. 3, 1817).—*Solen vagina* Linnaeus [Syst. Nat., ed. 10, p. 672, 1758, "Habitat in M. europaeo, Indico." Schumacher cited a reference to "Pl. VI. fig. 3, Chemn. 6 pag. 40. Tab. 4. fig. 28." According to Chemnitz the specimen represented in this figure "Sie wohnet in den ostindischen Meeren." Children (Quart. Jour. Sci. Lit. Art, Vol. 14, p. 83, pl. 4, fig. 26, October, 1823) also designated *Solen vagina* Linnaeus as type of *Solen*. Hanley (Ipsa Linn. Conch., p. 29, 1855) believed that this species was an East Indian form illustrated by Mawe (Linn. Syst. Conchyl., pl. 5, fig. 2, 1823) and this was accepted by Stewart (Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 289, 1930). Hedley (Proc. Linn. Soc. New South Wales, Vol. 38, Pt. 2, p. 275, 1913) believed *Solen vagina* to be a common species of north Queensland which included among its synonyms, *S. truncatus* Mawe *S. brevis* Gray, *S. fonesii* Dunker and *S. jonesii* Conrad. Dodge (Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 45, 1952) recently discussed this species and was convinced that the species name *Solen vagina* is applicable to the Recent European shell. The latter was illustrated by Sowerby in Reeve's Conch. Icon., Vol. 19, *Solen*, species 2, pl. 1, fig. 2, 1874. "Hab. Great Britain." Also Tryon, Struct. and Syst. Conch., Vol. 3, p. 129, pl. 106, fig. 6, 1884.]

Range. — Eocene to Recent. Recent from the intertidal zone to 400 meters (219 fathoms).

Description. — Shell long, straight, dorsal and ventral margins parallel, ovate in cross-section, ends gaping; beaks terminal or usually decidedly anterior; surface smooth; hinge with one tooth in each valve; ligament long, external; anterior muscle impression elongated, posterior one subovate; pallial line extends beyond adductors; sinus short, rather square.

Remarks. — Members of this genus all have long, narrow shells, and the animal burrows in sand or sandy mud to depths of 50 cm at an angle of about 60°. Most of the species live in shallow water.

Two species of *Solen* occur in Californian waters and six species have been recorded occurring in tropical and subtropical west American waters. Eleven or twelve species have been reported from strata of Tertiary age in the western United States. Eight species of this genus have been reported living in Japanese waters by Habe. (1128).

Key to Species of *Solen*

- A. Dorsal margin straight; very narrow in proportion to length *rosaceus*
- B. Dorsal margin slightly arcuate; moderately broad in proportion to length *sicarius*

Solen rosaceus Carpenter
Plate 48, Figure 12

Solen sicarius ? var. *rosaceus* Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 536, 638, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 22, 124, 1872.—Carpenter, Ann. Mag. Nat. Hist., Ser. 3, Vol. 15, p. 177, 1865. Reprint in Smithsonian Misc. Coll., No. 252, p. 279, 1872.

Solen rosaceus Carpenter, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 296, 1874. "Well at San Diego."—Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 265, 1888. "San Diego well."—Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 85, August, 1889. Dall's record (1874) cited.—Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 171, 1903. "San Diego well (Cooper)."—Orcutt, cited by Ellis in Ellis and Lee, U.S.G.S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited.—Weymouth, State Calif. Fish Game Comm., Fish Bull. No. 4, p. 50, pl. 15, fig. 3, 1920. San Diego, California, Recent. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 188, 1924. [Not pl. 49, fig. 6] "San Diego well."—Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48, 1944. Dall's record (1874) of San Diego well.—Fitch, Calif. State Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 76, fig. 42, 1953. "Humboldt Bay, California, to Mazatlan, Mexico." [Not the record "Humboldt Bay, California."]—K.V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 114, 1958. [Discussion of Carpenter's specimens.]—Pohlo, Veliger, Vol. 6, No. 2, pp. 98, 100 figs. 1, 2, 4, 1963. [Morphology and mode of burrowing.]

Type specimen.—"The type of this species has not been found." (Palmer, 1958.)

Type locality. — Cited as from "neighborhood of Sta. Barbara" and "The region between S. Diego and S. Pedro," California (Carpenter, 1864). "Hab. Sta. Barbara (Jewett; S. Pedro (Cooper))" (Carpenter, 1865). "Santa Barbara or San Pedro, California (type)" (Palmer, 1958).

Range. — Pliocene to Recent. Recent, from Santa Barbara, California, to Punta Peñasco and San Felipe in the Gulf of California and south to Mazatlan, Sinaloa, Mexico. Intertidal zone to 46 meters (25 fathoms). "Usually found at depths from a few inches to a foot or more in sandy mud of sheltered bays, sloughs and estuaries" (Fitch).

Occurrence in San Diego Fm. — San Diego well (Dall). C.A.S. 1182. S.D. 5006.

Original description. — Straight, narrower, longer, smaller; glossy, rosy. (Carpenter, 1864.)

Supplementary description. — S. testa *S. sicario* simili, sed minore; multo angustiore, elongata, recta, extus et intus rosacea; epidermide tenui, valde nitente. Long. .27, lat. .5, alt. .32 poll. (Carpenter, 1865.)

Remarks. — A cast of a small *Solen* collected at Loc. 4, (SD), on Mount Soledad, was identified as *S. rosaceus* by Mrs. Kate Stephens. The posterior end is lacking but the remainder is 29.2 mm long and 7.3 mm high. Another less perfectly preserved cast from the Loc. 1181 (CAS), also from Mount Soledad, is 21 mm long. The straight dorsal margin and the ratio of height

to length of both casts are comparable to Recent specimens of *S. rosaceus*. A portion of a cast, 15 mm long, collected at Loc. 34 (SD), northeast corner of India and Thorn streets, San Diego, may be referable to this species.

The shell of *Solen rosaceus* differs from that of *S. sicarius* Gould in that it is longer in proportion to the height and also in that the dorsal margin is straight rather than distinctly arcuate in outline.

Recent shells of *S. rosaceus* have rosy coloration rather than white as in Gould's species. Large specimens are often about 70 mm long. Johnson and Snook mentioned a very large specimen 75 mm long, 14 mm high and 19 mm in diameter.

It appears probable that records of this species from Miocene strata are referable to *Solen perrini* Clark. That species has a straight dorsal margin but has a thicker shell which also is much higher in proportion to the length than that of *S. rosaceus*. Clark's species was considered by Grant and Gale to be a subspecies of *S. sicarius*.

Solen tanozawaensis Nomura (1129) described from Miocene strata in Japan was compared by its author with *S. rosaceus* from which it differs in the more arcuate dorsal margin.

Weymouth (1920) mentioned concerning *S. rosaceus*, "it is interesting as being capable of a kind of 'swimming' though habitually found in burrows."

Solen sicarius Gould
Plate 49, Figure 7

Solen sicarius Gould, Proc. Boston Soc. Nat. Hist., Vol. 3, p. 214, May, 1850. — Gould, U. S. Explor. Exped. (Wilkes), Vol. 12, p. 387, 1852, Atlas, p. 13, pl. 33, figs. 501, 501a, 501b, 1856. — Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 204, 1909. Quillayute Formation, western Washington, Pliocene. Also "Purisima San Diego."—J.P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 174, 182, 1912. "San Diego - Purisima." — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 281, pl. 26, fig. 1, pl. 50 (chart), 1918. "Range. — Vancouver Island to San Quintin, Lower California (Orcutt)." — Weymouth, State Calif. Fish Game Comm., Fish Bull. No. 4, p. 50, pl. 15, fig. 2, 1920. British Columbia to Southern California, Recent. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 188, pl. 49, fig. 1; pl. 18, fig. 1, 1924. Various localities, Pliocene to Recent. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 385, pl. 21, fig. 4, 1931. Late Miocene to Recent. — Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 77, fig. 43, 1953. "Range: British Columbia to San Quintin Bay, Baja California."

Type specimen. — Holotype No. 11876, United States National Museum.

Type locality. — "Hab. Straits of De Fuca, Oregon." [Washington.]

Range. — Late Miocene (Briones; Santa Margarita; San Pablo) to Recent. Recent from Vancouver Island, British Columbia, to San Quintin Bay, Lower California, Mexico; littoral zone to 124 meters (68 fathoms), burrowing in mud or muddy sand to a depth of 15 to 20 inches

in bays, estuaries and sloughs.

Occurrence in San Diego Fm. — C.A.S. 1181, 1402, 28891. L.A.M. 305, 305A, 319. S.D. 4, 417.

Original description. — *T. transversa*, oblonga, retorsum angustata, subfalcata, epidermide crasso, nitido, corneo induta, anticè obliquè truncata, posticè rotundata: valvis valdè excavatis, undulatis, areis triangularibus indistinctè partitis; margine dorsali recto; m. ventrali arcuato; natis terminalibus: cardo dente triangulari, erecto, recurvo in utrâque valvâ instructa. Long. 3 1/2; lat. 7/20; alt. 9/10 poll. (Gould.)

Remarks. — One of the best preserved specimens of this species in the collections from the San Diego Formation, lacking only small portions of the ventral area, is one in the San Diego Society of Natural History from the south slope of Mount Soledad. It is 62.2 mm long, 14.9 mm high, the convexity (both valves together) 10.4 mm. This and other specimens from Balboa Park, in all observed characters, resemble Recent specimens of *Solen sicarius*. Large Recent specimens from adjacent waters attain a length of 75 mm and a height of 18 mm and specimens 88 mm long have been reported from Morro Bay, California. Fragments of this species are present from several localities near the Mexican boundary.

The shell of this species differs from that of *Solen rosaceus* in the larger size, gently arcuate rather than straight dorsal margin and on Recent specimens the color is greyish rather than rose.

Solen perrini Clark (1130), described from strata of late Miocene age, has a straight dorsal margin similar to that of *S. rosaceus*, but the flexure on the anterior end is more pronounced than on *S. sicarius*. This form is said to attain a length of 153 to 204 mm (six to eight inches) and a height of 25 to 38 mm (1 to 1 1/2 inches).

Solen clallamensis Clark and Arnold (1031) described from beds of middle Miocene age at Clallam Bay, Washington, bears a similarity to *S. sicarius* but it was said to differ in the more rounded anterior end and in that the anterior sulcus is situated farther from the end of the shell.

Small specimens about 40 mm in length from the Eugene Formation in western Oregon, believed to be of Oligocene age, were referred to *S. sicarius* by Hickman (1132).

"*Solen cf. sicarius* Gould" was cited as occurring in Formosa by Kuroda (1133), but apparently there is doubt concerning the identification because Kuroda and Habe (1134) include it with question in a check list of Japanese species. The general shape of *S. krusensterni* Schrenck as illustrated by Hirase (1135) is similar to that of *S. sicarius*.

The record of *Solen sicarius* from a Quaternary terrace in Ecuador (1136) is referable to some other species.

GENUS *ENSIS* SCHUMACHER

Ensis Schumacher, Essai nouv. Syst. Hab. Vers Testacés, p. 143, 1817. Species cited, "*Ensis magnus*" [Schumacher], pl. 14, fig. 1. Also mentioned were, "*Solen ensis* Lin. *Solen siliqua* Chemm. 6. pag. 44. Tab. 4, fig. 29."—Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 5, pp. 950, 954, 1900. "Type *S. magnus* Linné."—Cossmann and Peyrot, Act. Soc. Linn. Bordeaux, Tome 63

(Conch. Néogène de L'Aquitaine, Tome 1), Livr. 1, p. 150, 1909. "G.-T.: *Solen ensis* Linné."—Gardner, U. S. G. S., Prof. Paper 142-E, p. 217, 1928. "Type *Ensis magnus* Schumacher."

Type species (by tautonomy, and by subsequent designation by Herrmannsen, Indic. Gen. Malcozoo., Vol. 1, p. 423, 1846).—"Typus: *Solen ensis* Linn." [Syst. Nat., ed. 10, p. 672, 1758. "Habitat in M. Mediterraneo, Anglico." Ref. to "List, angl. app. t. 2. f. 9" and "Argenv. conch. t. 27. f. L? Also illustrated by Sowerby in Reeve's Conch. Icon., Vol. 19, *Solen*, species 3, pl. 1, fig. 3, 1874. "Hab. Great Britain."—Van Urk, Basteria, Vol. 28, No. 1 and 2, p. 37, pl. 1, fig. 4, 1964. "North Sea-Mediterranean." For discussion of this species see Dodge, H., Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, pp. 34-35, 1952.]

Range.—Eocene; Miocene to Recent. Recent, world wide in warm temperate and tropical waters, in soft inshore sands and muds, but also offshore (off Florida) to a depth of 91 meters (50 fathoms), and perhaps deeper.

Description. — Valves thin, scabbard-shaped, slightly gaping, usually somewhat arcuate; umbones flattened, subterminal; ligament external, opisthodontic; hinge of right valve armed with one vertical and one horizontal lamelliform cardinal, that of the left valve with two proximate vertical cardinals and one horizontal; anterior adductor impression conspicuous, elongated in the general direction of the major axis; pallial line rather distant from the ventral margin, sinuate posteriorly (Gardner, 1928.)

Remarks. — Some authors place the genus *Ensis* in the family Cultellidae.

The presence of *Ensis* in beds of Tertiary age in western North America is reported here for the first time. However, it has been reported from beds of Pleistocene age in this region by several authors. One species now lives in warm temperate waters in this region and two in southern tropical waters. This genus is known to occur in Florida and in Europe in strata of Miocene age.

Holmes (1137) gave an excellent discussion of the three Recent British species including their ecology and more recently Van Urk (1138) discussed the European species of *Ensis*. Some species of *Ensis* are described as able to move about very quickly in their burrows.

Ensis myrae Berry Plate 57, Figures 7, 19

Ensis californicus Dall, I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 189, pl. 49, fig. 6, 1924. "San Pedro." [The plate and figure are erroneously cited under the caption to *Solen sicarius* Gould, p. 188.]

Not *Ensis californicus* Dall, 1899.

Ensis myrae S. S. Berry, Trans. San Diego Soc. Nat. Hist., Vol. 11, No. 15, pp. 398, 399, figs. 3, 4, August 14, 1953.

Type specimen. — No. 7582, Stanford University.

Type locality. — "San Pedro Bay, California; mainly cast up by storms in the vicinity of Terminal Island."

Range. — Middle Pliocene to Recent. Recent from Monterey, California, to Islas Los Coronados, Lower California, in 14 to 46 meters (8 to 25 fathoms) to 91 meters (50 fathoms) according to Valentine and Mead

(Univ. Calif. Publ. Geol. Sci., Vol. 40, No. 1, p. 26, 1961).

Occurrence in San Diego Fm. — C.A.S. 28889, 28892. L.A.M. 107, 305, 305A, 318, 319.

Original description. — Shell of moderate size and slenderness, rather strongly falciform; valves narrowing slightly and rather sharply and squarely truncate in front, more rounded and narrowing a little more steadily and decidedly posteriorly. Hinge-plate strongly anterior in position, small and comparatively short; right major cardinal compressed, squarish in profile, strongly projecting; right posterior cardinal slender, short (appreciably less than one-tenth the length of the shell), laminar, terminating in a short free flange; left major cardinals strongly unciform and considerably heavier than that in the right valve; inner left posterior cardinal generally similar to its mate of the right valve, the weaker outer cardinal closely adnate to the shell margin. Exterior of shell mostly with a somewhat silky sheen due to the numerous fine growth-striae underlying the thin shining Sayal Brown to Mikado Brown periostracum; in adult shells the periostracum is usually rubbed away in a blade-shaped swath extending from the beaks to the posterior margin, this area being white except for some ruddy or purplish coloring, especially along the edges of the area and in the incremental rest-marks, where the Deep Rose Pink or Vinaceous tinting of the interior may shine through. Maximum longitude, 81.3 mm., altitude, 11.9 mm., percentage of altitude to length, 14.6 mm., diameter 5.8 mm. (Berry.)

Remarks. — One fairly well preserved right valve of an *Ensis* and many fragments from Locs. 305 and 305A (LAM), and fragments from Loc. 319 (LAM), all from near the Mexican boundary, are present in the collections of the Los Angeles County Museum. These agree in all observable details with Recent shells of *Ensis myrae* Berry. The large right valve is 63.9 mm long and 10 mm high. A cast retaining portions of the shell material, from Loc. 28892 (CAS), also from near the Mexican boundary, appears to be referable to *E. myrae*.

This species was described as differing from *E. californicus* Dall (1139) in the greater size, less slender outline, greater arcuation, squarish rather than rounded anterior end, the pallial line nearer the margin, and in minor details of the hinge.

We have not studied a series of specimens of *E. californicus* but the single valve from Manzanillo, Mexico, reported by Hertlein and Strong (1140), 60.5 mm long, and 7.3 mm high, has an outline more slender than that of *E. myrae* but the anterior end much less rounded than that shown in Berry's (1141) drawing of a specimen of *E. californicus* from San Felipe, in the Gulf of California.

The ratio of height to length of the type of *E. californicus* is 12.1, of the left valve reported from Manzanillo, Mexico, 11.7, that of the type of *E. myrae* 14.6 and that of the right valve from the San Diego Formation, 15.6.

The only other species of *Ensis* described from eastern Pacific waters is *Ensis tropicalis* Hertlein and Strong (1142), the outline of which is only slightly arcuate and in this character it resembles some species of *Solen*.

Ensis myrae, at times, has been mistaken for *Solen rosaceus*. The nearly straight anterior end of the pallial line and the gently obliquely sloping anterior retractor muscle impression are features which aid in separating even

fragments of the anterior end (when the interior is exposed) from Carpenter's species. The corresponding muscle impression on *S. rosaceus* is wider and parallel to the dorsal margin of the valve.

GENUS *SILIQUA* MEGERLE VON MÜHLFELD

Siliqua Megerle von Mühlfeld, Gesell. f. Naturfor. Freunde zu Berlin, p. 44, 1811. Sole species: *Siliqua radiata* Linnaeus. Ref. to "Linn. Syst. Nat. Gen. 304. Sp. 6" and "Chemn. Conch. 6, t. 5. f. 38. -40." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 386, 1931. Type, *Solen radiatus* Linnaeus.

Leguminaria Schumacher, Essai Nouv. Syst. Hab. Vers Test., p. 126, 1817. Type (by monotypy): *Leguminaria costata* Schumacher, p. 126, pl. 7, fig. 1 [= *Solen radiatus* Linnaeus].

Machaera Gould, Invert. Massachusetts, p. 32 1841. *Solen radialus* Linnaeus and other species cited.

Not *Machaera* Cuvier, 1832.

Type species (by monotypy). — "*Siliqua radiata*" Linnaeus [= *Solen radiatus* Linnaeus, Syst. Nat., ed. 10, p. 673, 1758. "Habitat in O. Asiatico." Ref. to "Rumph. mus. t. 45. f. E."; "Gault. test. t. 91, f. B."; "Argen. conch. T. 25. f. P." Illustrated by Sowerby in Reeve's Conch. Icon., Vol. 19, *Cultellus*, sp. 13, pl. 4, fig. 13, 1874. "Hab. Sumatra." For a discussion of this species see Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, art. 2, p. 36, 1952.]

Range. — Late Cretaceous?; Eocene to Recent. Recent from the intertidal zone to about 55 meters (30 fathoms).

Description. — Shell oblong, length about three times as great as the height, somewhat compressed, smooth, ends rounded, gaping, beaks about one third to one fourth the distance from the anterior end; interior of valves with a flattened rib posterior to anterior muscle impression, extending from beneath the beaks to the ventral margin; hinge with 2 small, close cardinals in the left valve and one in the right; pallial sinus large, short, rounded.

Remarks. — *Siliqua alisoensis* Packard (1143) was described from strata of late Cretaceous age in the Santa Ana Mountains in southern California. An internal rib was present on the anterior portion of the shell. The hinge was not described and there may be doubt as to whether this species is referable to *Siliqua* or to some similar genus *Leptisolen* Conrad, a Cretaceous genus, also has an internal rib. *Senis* Stephenson, which resemble *Siliqua* in external features, is said to lack hinge teeth. The genus *Siliqua* has been recorded from strata of Eocene age in Texas (1144) and in Japan (1145). Gardner (Univ. Texas Bull. 3301, p. 188, 1935) reported "*Siliqua?* sp." from the upper Midway Group now believed to be of Paleocene age.

No species of *Siliqua* have been reported from the early Tertiary strata of California but the genus is definitely known to occur from late Miocene (Briones) to Recent. It has been reported from western Oregon in beds of middle Miocene age and in northern California in strata of late Miocene age and in beds of Pliocene age.

Siliqua is essentially an inhabitant of cool waters.

Five species are known to occur in west American waters between the Arctic Ocean and Todos Santos Bay, Lower California. According to Paul Bonnot (1146), *S. patula* lives in sand close to the surface, the hinge toward the sea.

This genus was included in the family Cultellidae by Keen in 1969.

Siliqua lucida Conrad
Plate 49, Figure 2

S[olecurtus]. lucidus Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 231, pl. 17, fig. 8, 1837.

Siliqua lucida Conrad, I.S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 189, pl. 52, fig. 2, 1924. "Range. Monterey, California, to Todos Santos Bay, Lower California. In the Pleistocene at San Pedro and San Diego, California."—Johnson and Snook, Seashore Animals of the Pacific Coast (Macmillan and Co.: New York), pp. 458, 460, fig. 458, edit. 1935. Monterey, California, to Lower California. — Morris, A Field Guide to Shells of the Pacific and Hawaii (Houghton Mifflin Co.: Boston), p. 55, pl. 14, fig. 6, 1952. Bolinas Bay, California, to Mexico.—Hertlein, Bull. South. Calif. Acad. Sci., Vol. 60, Pt. 1, pp. 14-15 (in text), pl. 5, figs. 4, 5, 6, 1961. From breakwater at North Island, Los Angeles County, California, Recent.

Type specimen. — Syntypes, four valves, Nos. 61.5. 20.133 (3 valves) and 57.8.14.2 (single valve), British Museum (Natural History) (A. M. Keen, Veliger, Vol. 8, No. 3, p. 170, 1966).

Type locality. — "Inhabits the sand-beach, near Sta. Barbara; uncommon."

Range. — Late Miocene (Briones) to Recent. Recent from Bolinas Bay, California, to San Quintín Bay, Lower California, Mexico, on sandy beaches and to the depth of 46 meters (25 fathoms).

Occurrence in San Diego Fm. — L.A.M. 107, 305, 305A, 319. S.D. 83. U.C.L.A. 1386.

Original description. — Shell oblong, oval, compressed, thin, fragile, translucent; posterior extremity nearly direct, truncated; colour blueish, with purple concentric zones, and two oblique pale rays on the posterior side; interior rib nearly direct. (Conrad.)

Remarks. — One specimen retaining much of the shell and four others less perfectly preserved were collected by Frank Stephens on Reynard Way in San Diego. The largest specimen (incomplete) is 36.5 mm long. The shape and observable characters of this and the accompanying specimens are comparable to Recent specimens of *Siliqua lucida* of the same size. Recent specimens 55 mm long have been reported from Morro Bay, California. Two imperfect casts from Kensington Park, San Diego, may be referable to this species. Two small single valves about 18 mm long and a left valve 28.5 mm long, from Loc. 107 (LAM), appear to be referable to this species. The anterior portion of a left valve, about 18 mm long from Loc. 305 (LAM), agrees in shell characters with the corresponding portion of a Recent valve of *S. lucida*. Many fragments, probably referable to this species, are present in the collections of the Los Angeles County Museum from Locs. 107, 305, 305A, and 319.

The shell of *Siliqua lucida* is separable from that of

young specimens of *S. patula* in that it is smaller and much more elongate, the ventral margin is more arcuate, the anterior end is shorter and the posterior end is somewhat more truncated. The shell of *S. lucida* is very thin and the exterior of live specimens is gray tinged with violet, whereas that of *S. patula* is covered with a shiny, light brown periostracum. The interior rib of the present species is nearly vertical rather than inclined anteriorly and in this character it more resembles the northern *S. media* Sowerby.

Siliqua sloati Hertlein (1147), a Recent species described from off California, differs from *S. lucida* in the more roundly pointed posterior end and in the less expanded posterior dorsal area which is not bordered by a distinct groove.

An intensive study of *Siliqua patula* Dixon, a large form of commercial value, was made by Weymouth, et al. (1148) According to those authors, *S. patula* attains a maximum age of 19 years. Large specimens are 170 mm long.

SUPERFAMILY MACTRACEA BOWDICH (1149)
FAMILY MACTRIDAE BOWDICH (1150)

Shell roundly trigonal or oblong; closed or slightly gaping; lunule and escutcheon not well defined; surface usually marked only with lines of growth, rarely with strong concentric sculpture; beaks inclined anteriorly; ligament opisthodontic, short; resilium triangular or ovoid and situated in a deep pit, usually on a downward projecting hinge-plate (chondrophore) which is posterior to the cardinals; hinge of left valve usually with one bifid V-shaped cardinal, sometimes with accessory shelly processes, and usually with an anterior and a posterior lateral tooth; all these fit into sockets or paired laminae in the right valve; pallial sinus well developed; adductor impressions subequal, peripheral. Cretaceous to Recent.

Remarks. — This family includes a number of gen-

Key (1158) to Genera and
Subgenera of Mactridae

- A. Shell broadly gaping posteriorly;
outline ovately
rectangular *Tresus*
- B. Shell narrowly gaping or
closed; outline usually
ovately subtrigonal.
 - a. Chondrophore separated from
resilium by a shelly
lamina *Mactra* (1159)
 - aa. Chondrophore not separated from
resilium by a shelly lamina.
 - b. Lateral teeth moderately long;
beaks nearly centrally
situated *Spisula* s. s.
 - bb. Lateral teeth short; beaks
more anteriorly
situated (subgenus) *Mactromeris*

era and subgenera. About a dozen species have been recorded from Pliocene strata of California, Oregon, and Washington. Eleven species occur in marine waters between the Bering Sea and San Diego, California, and 24 species have been recorded living in tropical and subtropical waters of the western Americas.

The family Mactridae has been the subject of special studies by Gray (1151), Dall (1152), and Lamy (1153). A paper by Packard (1154) deals with Mesozoic and Cenozoic Mactridae of western North America, chiefly north of Mexico and papers by Hertlein and Strong (1155), by Keen (1156), and by Olsson (1157) contain discussions of a number of tropical west American species.

GENUS *SPISULA* GRAY

Spisula Gray, Mag. Nat. Hist., New Ser., Vol. 1, p. 372, July, 1837. Many species cited including "*Spisula sólida*; *Mactra sólida* Montague" (p. 374).—Dall, Trans. Wagner Free. Inst. Sci., Vol. 3, Pt. 4, p. 895, 1898. — Lamy, Jour. de Conchyl., Vol. 63, No. 4, p. 291, 1918. Type: *Mactra sólida* Linnaeus. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 2, p. 393, 1931. Type: *Mactra sólida* Linnaeus as indicated by Gray, 1847. — Olsson, Mollusks of the Tropical Eastern Pacific Paleo. Res. Inst.: Ithaca, New York, p. 326, 1961. Type as indicated by Gray.

Type species (designated by Gray, Proc. Zool. Soc. London for 1847, p. 185). — "*M. sólida*". [= *Cardium solidum* Linnaeus, Syst. Nat., Ed. 10, p. 681, 1758. "Habitat in O. Anglico." Ref. to "Bonan. recr. 3. t. 51"; "Rond. test. 1. c. 7"; "List Angl. 174, t. 4. f. 24". — Lamy, Jour. de Conchyl., Vol. 63, No. 4, p. 295, figs. of hinge (p. 292), 1918. (With synonym.). — Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 75, 1952.]

Key to Species of *Spisula*

- A. Valves compressed; adult shell usually less than 70 mm long.
 - a. Shell subtrigonal; beaks nearly central *planulata*
 - aa. Shell elongately trigonal; beaks decidedly anterior *falcata*
- B. Valves inflated; adult shell usually more than 70 mm long.
 - a. Beaks posterior to the middle of valves *hemphilli*
 - aa. Beaks anterior to the middle of valves.
 - b. Posterior flexure distinct; ovately elongate in outline or ovately subtrigonal. *catilliformis*
 - bb. Posterior flexure indistinct; very elongate in outline, the beaks more anteriorly situated *mercedensis*

Range. — Middle Eocene to Recent. Recent from the littoral zone to 110 meters (60 fathoms): occasionally deeper.

Original description. — Shell ovate, trigonal, subangular at each end. Hinge and lateral teeth as in *Mactra*; but hinge tooth of left valve very small. Siphonal inflection ovate, distinct. Ligament just within the cardinal edge, over the top of the cartilage, and not separated from it by any shelly plate; and partly hid from view by the hinge margin. (Gray.)

Remarks. — The generic and subgeneric assignment of many species to *Mactra* or to *Spisula*, especially fossil forms, is doubtful due to the difficulty of detecting whether or not the resilium is separated from the ligament by a shelly lamina. Five species which occur in the San Diego Formation are referable to *Spisula* (1160).

Eight species referred to *Spisula* have been reported as occurring in strata of Pliocene age in western United States. Six species are known to occur in marine waters between the Bering Sea and San Diego, California.

[*Mactra albaria* Conrad]

Mactra albaria Conrad, Amer. Jour. Sci., Ser. 2, Vol. 5, p. 432, fig. 4, 1848. Reprint by Dall, U. S. G. S., Prof. Paper 59, p. 150, fig. 4, 1909. — Dall, cited by Ellis in Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 63, 1919.

Type specimen.—"Holotype: Missing and presumed lost." (Moore, Ellen, U. S. G. S., Prof. Paper 419, p. 83, 1963.)

Type locality.—"Near Astoria. . . Tertiary." [Middle Miocene.]

Range. — Miocene.

Occurrence in San Diego Fm. — "About 3 1/4 miles east of Chula Vista and 1 1/4 miles southeast of Bonita the north wall of a small canyon, locally known as Fossil Canyon. . . about 300 feet above sea level." (Dall, cited by Ellis in Ellis and Lee.)

Remarks. — The only record of the occurrence of this species in the San Diego Formation is that of Dall cited by Ellis. *Mactra albaria* was originally described from Astoria, Oregon, where it occurs in beds of middle Miocene age. It has been recorded as occurring in beds of Pliocene age in northern and central California, as well as in Oregon and Washington, but it has not been recorded from Pliocene strata in the Los Angeles basin nor south of there.

Spisula albaria var. *coosensis*. (1161) from the Pliocene of Coos Bay, Oregon, was described by Howe. This form attains a large size and lacks the pronounced angulation such as occurs on *S. albaria* from the beak to the posterior (1162) ventral margin. Howe also mentioned differences in the hinges of the two forms. Those from Astoria "show the left cardinal to extend uniformly from the beaks to the edge of the chondrophore, while in var. *coosensis* the left cardinal extends only two-thirds of this distance." There also is said to be a difference in the characters of the hinge of the right valve of the two forms. Weaver (1163) cited the range of *S. albaria* as "Upper Miocene to Recent", but so far as known it does not occur in the post-Miocene fauna. It appears likely that Pli-

ocene records of *S. albaria* may be referable to *S. a. coosensis*.

In view of the fact that neither *Spisula albaria* nor *S. a. coosensis* has been observed in any of the collections from San Diego and as the sole record is that of Dall in a general faunal list by Ellis, we are inclined to consider this to be an invalid record for the San Diego Formation.

SUBGENUS *MACTROMERIS* CONRAD

Mactromeris Conrad, Amer. Jour. Conch., Vol. 3, Cat. Mactridae, ap. p. 45, January 2, 1868. Seven species (including several synonyms) cited of which *S. ovalis*, Gould, is first. — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 207, 1930. "Type species *Mactra ovalis* Gould, designated by Stoliczka." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 394, 1931. "Type (by subsequent designation, Dall, 1898), *M. polynyma* Stimpson." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 323, 1961. "Type species by subsequent designation, Dall, 1898, *Spisula ovalis* Gould (= *Mactra polynyma* Stimpson)."

Symmorphomactra Dall, Nautilus, Vol. 8, No. 4, p. 41, August, 1894. Sole species. "*Spisula* (*Symmorphomactra*) *falcata* Gld., 1850. Comox, Br. Col. to San Pedro, Cala."

Type species (designated by Stoliczka, Mem. Geol. Surv. India, Palaeont. Indica, Ser. 6, Vol. 3, Pelecypoda, p. XVI, 1871. — "*St. ovalis*, Gray," (on p. 53 cited as "*Standella ovalis*, Gould") [= *Mactra ovalis* Gould, Amer. Jour. Sci., New Ser., Vol. 38, p. 196, 1840. [No locality cited.] — Gould, Invert. Massachusetts, p. 53, pl. 3, fig. 32, 1841; ed. by Binney, 1870, p. 75, fig. 32. (Not *Mactra ovalis* G. B. Sowerby, 1818. Crag, Pliocene of England). Gould's species was renamed *Mactra polynyma* by Stimpson, Smithsonian Misc. Coll., Vol. 2, Art. 6, No. 3, p. 3, 1860. For synonymy of this species see Lamy, Jour. de Conchyl., Vol. 63, No. 4, p. 319, hinge illustrated p. 198, 1917.]

Range. — Miocene to Recent. Recent in boreal and warm temperate waters. One or two species in tropical west American waters have been referred to *Mactromeris*.

Description. — Shell of moderate or large size; beaks more anteriorly placed than in *Spisula s. s.*; hinge of left valve with small accessory lamina posterior to the cardinal tooth, right valve with anterior cardinal separate from lower anterior lateral; lateral teeth smooth. (Adapted from Lamy, and Grant and Gale.)

Remarks. — The hinges of many of the groups of Mactridae are quite similar. The group segregated under *Mactromeris* possess a hinge similar in general features to *Spisula s. s.* as mentioned by Stewart. They differ in that the laterals are proportionately shorter, the beaks are more anteriorly situated and the pallial sinus is longer.

A subgenus of *Spisula*, *Symmorphomactra*, was proposed by Dall in 1894 with the sole species *Spisula* (*Symmorphomactra*) *falcata* Gould. This subgenus was described as "teeth of *Mactrotoma*, s. s., hinge of *Spisula*." The following year Dall (1894) did not cite this category in his synopsis of the Mactridae. In 1921 he (1894) placed *Spisula falcata* in the subgenus *Hemimactra*,

section *Mactromeris*, and referred only one species, *S. planulata* Conrad, to *Symmorphomactra*.

Some authors consider *Symmorphomactra* to lack systematic value. The current classification of genera and subgenera of west American Mactridae is not entirely satisfactory. For the present we have *S. falcata* and *S. planulata* in *Mactromeris*.

The hinge of *Hemimactra* Swainson (1866) differs from that of *Mactromeris* in that the cardinals are almost obsolete and the laterals are transversely striated.

Recent species of *Mactromeris* are almost restricted to the region encompassed by boreal to warm temperate waters along both coasts of North America and Japan. There are about six species living in west American waters and about the same number of species have been described as fossils in that region.

Spisula (*Mactromeris*) *catilliformis* Conrad Plate 54, Figures 5, 7

Spisula catilliformis Conrad, Amer. Jour. Conch., Vol. 3, No. 2, p. 193, September 5, 1868. — Conrad, Amer. Jour. Conch., Vol. 5, Pt. 2, p. 108, pl. 13, fig. 1, October 7, 1869.

Mactra (*Spisula*) *catilliformis* Conrad, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 62 ("Pacific Beach," "Pliocene"), p. 176 "Pliocene. — San Diego (Arnold)", pl. 19, fig. 5 ("Upper San Pedro series, San Pedro"), 1903. — Arnold, U.S.G.S., Prof. Paper 47, p. 28, 1906. "San Diego formation as developed in the type section at Pacific Beach north of San Diego." — Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 202, 1909. "Purisima-San Diego." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 398, pl. 23, figs. 4 and 10 (from Etchegoin), 1931. "Pacific Beach, San Diego (Arnold, 1903.)"

Mactra catilliformis Conrad, J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 172, 1912. "San Diego-Purisima." Pliocene.

Spisula catilliformis Conrad, Packard, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 9, No. 15, p. 285, pls. 17, 18, 19, May 1, 1916. Middle Miocene to Recent. — Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 282, pl. 27, figs. 1, 2; pl. 24, fig. 2, 1918. "Range. — Straits of Juan de Fuca, Washington, to San Diego, California." I.S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 194, pl. 24 (reproduction of pl. 17 of Packard, 1916), 1924. "Pliocene at San Diego." Also other occurrences. Recent from "Neah Bay, Washington, to San Diego, California." — Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 87, fig. 53, 1953. "Range: San Francisco Bay to San Diego Bay." — Abbott, American Seashells (D. Van Nostrand Co.: New York), p. 448, fig. 90c, 1954. Washington to Ensenada, Lower California

Type specimen. — Location unknown to the present authors.

Type locality. — "Inhabits Panama" [As stated by Dall (Nautilus, Vol. 7, No. 12, p. 137, pl. 5, fig. 3, 1894), this species was "erroneously stated to have come from Panama." In this paper Dall cited the distribution as "Neeah Bay to San Diego, Cala."]

Range.—“cf.” Early and middle Miocene (Vaqueros and Temblor formations); late Miocene to Recent. Recent, from Neah Bay, Washington, to San Quintín Bay, Lower California, in 18 to 73 meters (10 to 40 fathoms), occasionally in shallower water. “Lives in fine sand or firm sandy mud in bays, sloughs and estuaries as well as more quiet protected areas along the outer coast” (Fitch).

Occurrence in San Diego Fm. — C.A.S. 1140, 1182, 1400. L.A.M. 104, 107, 305, 305A, 309, P.87, A-1323.

Original description. — Suboval, inequilateral; anterior side slightly flattened or contracted; posterior side with an oblique shallow groove or fold; lines of growth coarse and prominent; lunule very long, elliptical; ventral margin tumid posteriorly; cardinal pit oblique, large; pallial sinus extending beyond the middle of the valve. Length $4 \frac{5}{8}$ inches; height $3 \frac{7}{8}$ inches. (Conrad.)

Remarks. — A number of specimens of *Spisula catilliformis*, in various states of preservation, are present in the collections from the San Diego Formation. There is variation in the outline of a series of specimens, some are decidedly more triangular than others. A large cast, retaining some shell material, from Loc. 107 (LAM), at the end of Arroyo Drive, San Diego, is 129.5 mm long and 99 mm high. Another smaller cast from the same locality is 92 mm long, 71 mm high, convexity (both valves together), 47 mm. A specimen retaining most of the shell material from Loc. 305 (LAM), near the Mexican boundary, is 124 mm long, 102 mm high, convexity (both valves together) 62 mm. The beaks are approximately 57 mm from the anterior end of the shell. A Recent specimen, in the collections of the California Academy of Sciences, from Halfmoon Bay, California, is 134 mm long, 104 mm high, convexity (both valves together) approximately 61 mm, beaks situated about 49 mm from the anterior end of the shell, and the pallial sinus extends forward about 49 mm from the posterior end of the shell. A smaller specimen from Loc. 37138 (CAS), Monterey, California, is 109 mm long, 81 mm high, convexity (both valves together) 50 mm, the beaks are about 45 mm from the anterior end of the shell. The hinges as well as the other shell characters of the fossils are all comparable to Recent specimens of the same size.

The fossils from beds of Pliocene age in the Santa Maria district, California, cited by Woodring (1167) under the name “*Spisula* cf. *S. catilliformis* Conrad” were said to refer to the short, rounded form described from that area by Arnold under the name of *Spisula catilliformis* var. *alcatrazensis* (1168). He mentioned, however, that no Recent specimens of *S. catilliformis* are as short as the fossils from Santa Maria.

Spisula (Mactromeris) cf. *S. (M.) falcata* Gould
Plate 54, Figure 8; Plate 57, Figure 12

The following references, type locality, range and description refer to typical *S. falcata*.

Mactra falcata Gould, Proc. Boston Soc. Nat. Hist., Vol. 3, p. 216, May, 1850. — Gould, U. S. Explor. Exped. (Wilkes), Vol. 12, p. 393, 1852, Moll., Atlas, p. 13, pl. 34, figs. 506, 506a, 506b, 1856. — Gould, Otia Conch., p. 76, 1862. [Original description reprinted.]

Spisula planulata Conrad, Packard, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 9, No. 15, p. 293, pl. 16, figs. 3a, 3b, 3c, 1916.

Not *Mactra planulata* Conrad, 1837.

Spisula falcata Gould, I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 60, pl. 17, figs. 1-3, 1924. [Reproductions of Gould's original illustrations, figs. 506, 506b.] “Puget Sound to Cortez Bank and the Coronado Islands, Mex.” — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 195, pl. 20, figs. 1-3, 1924. [Reproduction of Gould's original illustrations, 506, 506b.]

Type specimen. — No. 5893, United States National Museum.

Type locality. — “Hab. Puget Sound, Oregon.” [Washington.]

Range. — Middle Pliocene (1169) to Recent. Recent from Queen Charlotte Islands, British Columbia, to San Diego, California, and Cortez Bank, and Coronado Islands, Mexico, in 4 to 50 meters (2 to 24 fathoms).

Occurrence in San Diego Fm. — L.A.M. 305A.

Original description of *Mactra falcata*. — Testa magna, transversa, ovatotrigona, inequilateralis, convexiuscula, modice hians, albidula, epidermide fulvo, nitido, concentricè rugoso induta; umbonibus acutis, approximatis; latere antico acuminato; latere siphonali latè rotundato, sub-truncato; margine dorsali recto; areâ dorsali planulata, lanceolatâ; margine ventrali leniter arcuato; area cardinalis ampla; fossâ ligamentali magnâ, dente V-formi parvo, classo, dentibus lateralibus compressis, quorum antico valvae dextrae bilobato; interior lactea; sinu siphonali angusto, elongato, spatulato. Long. $3 \frac{3}{4}$; alt. $2 \frac{1}{2}$; lat. $1 \frac{1}{8}$ poll. (Gould.)

Remarks. — The specimen here provisionally identified as *Spisula falcata* is a small right valve 18 mm long and 11.6 mm high. The preservation is imperfect, but the very inequilateral outline and the remnant of the hinge agree well with juvenile specimens of *S. falcata*.

Reagan (Trans. Kansas Acad. Sci., Vol. 22, p. 204, 1909) reported “*Mactra (Spisula) falcata* Gould” from the Quillayute Formation in western Washington of Pliocene age and also from the “Purísima-San Diego” formation. This record from San Diego, however, is equivocal in that two formations from California are mentioned.

Spisula falcata brioniana Trask (1170) from the Briones Formation of late Miocene age, was described as differing from the typical species in the greater height in proportion to the length, more prominent umbonal ridge, shorter hinge plate and shorter distance from the center of the hinge plate to the distal ends of the lateral lamellae.

Spisula falcata bears a resemblance to *S. dolabriformis* Conrad (1171), which also is an elongated form, but may be separated from it by the character of the hinge. The right anterior accessory lamina extends toward and is separated from the lower lateral by only a slight gap whereas in *S. dolabriformis* the corresponding lamellae are offset and separated by a comparatively wide space. The same difference in the hinge also exists between *S. falcata* and *S. planulata* Conrad. The latter is much more equilateral and the shell is thicker.

Spisula (Mactromeris) hemphillii Dall
Plate 54, Figures 1-4, 9, Plate 57, Figure 16

Mactra hemphillii Dall, Nautilus, Vol. 7, No. 12, p. 137, pl. 5, fig. 2, April, 1894. "Distribution: San Diego, Hemphill and Cooper." Recent. — Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 204, 1909 (as *Mactra hemphillii*). Quillayte Formation, western Washington, Pliocene. Also "Purisima-San Diego."

Spisula hemphillii Dall, Packard, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 9, No. 15, p. 287, pls. 21 and 22, May 1, 1916. Earlier records cited, Recent and Pleistocene. J. Q. Burch, Min. Conch. Club South. Calif., No. 44, p. 19, figs. (on p. 11 by T. A. Burch), February, 1945. "Redondo Beach, Calif. (Burch) to Corinto, Nicaragua [Nicaragua] (Eyerdam)" (1172).

Spisula hemphillii Dall, I. S. Oldroyd, Stanford Univ. Publ. Univ. Serv. Geol. Sci., Vol. 1, p. 194, pls. 46, 50 (reproduction of pls. 21, 22, by Packard, 1916), 1924. "Range San Pedro to San Diego, California, In the Pleistocene at San Pedro." — Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 83, 1929. "Pliocene of San Diego." Also "Purisima formation." — Fitch, State Calif., Dept. Fish Game, Mar. Fish. Branch, Fish Bull., No. 90, p. 88, fig. 54, 1953. "Range: Santa Barbara, California, to Ensenada, Baja California." — Abbott, American Seashells (D. Van Nostrand Co., Inc.: New York), p. 448, fig. 90b (p. 447), 1954. [Reproduction of Dall's (1894) illustration.]

Type specimen. — No. 15815, United States National Museum.

Type locality. — "San Diego," California.

Range. —? Late Miocene (Grant and Gale); Middle Pliocene to Recent. Recent, Monterey (1173) (rarely) Santa Barbara, California, to Todos Santos Bay, Lower California, Mexico, from intertidal zone (rarely) to 46 meters (25 fathoms); "in fine or firm, sandy mud in bays, sloughs and estuaries as well as more quiet protected areas along the outer coast" (Fitch).

Occurrence in San Diego Fm. — C.A.S. 1402, 28892. L.A.M. 107, 305, 305A, P.87, A-1323. S.D. 29, 331, 2939, 2946, 3592. U.C.L.A. 294, 312.

Original description.—Shell large, thin, inflated, subequilateral, creamy white with a yellow thin epidermis, which over the body of the shell in young shells is beautifully evenly concentrically striated and on the posterior dorsal area is irregularly wrinkled, with an elevated raphe of epidermis at the margin of the area; beaks rather prominent, the anterior end of the valves longer than the posterior; posterior dorsal slope excavated; lunule obscure, escutcheon marked by prominent elevated radial lines of epidermis; the dorsal margin pouting in front of the ligament, the posterior slope convex, the posterior flexure faint, but marked by a recession of the ventral border of the valves, which gape but very little and not at all in front; anterior end rounded, but smaller than the posterior; ventral border arcuate; hinge and pallial sinus much as in the last species [*Mactra catiliformis*] except that the sinus is somewhat smaller and less depressed. Lon. 120, alt. 93, diam. 50 mm. (Dall.)

Remarks. — Several well preserved specimens and many fragments of *Spisula hemphillii* from the San Diego Formation agree in all observable details with part of the

type lot of that species. The largest specimen from Loc. 2946 (SD), from Reynard Way, San Diego, retaining most of the shell material, is 134.4 mm long, 102 mm high, convexity (both valves together) 48.8 mm. A specimen from Fossil Canyon east of Chula Vista [Loc. A1323 (LAM)], retaining patches of shell material, is 132.8 mm long, 104 mm high, convexity (both valves together), 58 mm. A smaller specimen, a right valve from Loc. 305 (LAM), near the Mexican boundary, is 114 mm long, 85 mm high, convexity 24 mm. Additional specimens from near the Mexican boundary in various states of preservation, are referable to this species.

A specimen from Loc. 28892 (CAS), from near the Mexican boundary, is 42 mm long, 31 mm high, convexity (both valves together), 17.4 mm. It agrees in all observable details with juvenile specimens in the original lot of *S. hemphillii*.

Five Recent specimens in the collections of the California Academy of Sciences, collected at San Diego by Henry Hemphill, apparently are part of the original lot upon which the species was based. The largest specimen is 133 mm long, 102 mm high, the convexity (both valves together) 51.3 mm. The pallial sinus extends forward 55 mm from the posterior end of the shell.

Grant and Gale (1931, p. 398) pointed out that there appears to be but little if any difference between the form described as *Spisula cameronis* Dall (1174), from beds of Pleistocene age at San Quintin, Lower California and *S. hemphillii*. It may be mentioned also that a decided similarity exists between two other species, *Spisula mossbeachensis* Glen (1175), a Pliocene species from the lower portion of the Merced Formation, and *S. longa* Dall (1176) from the Pleistocene at San Quintin. Judging from the illustrations, the form described as *Spisula (Mactromeris) hemphillii* var. *orcutti* Manager (1177) is a little higher in proportion to the length, the anterior end is a little broader and the pallial sinus is shorter, broader, and joins the pallial line at a greater angle than that of typical *S. hemphillii*.

The shell of *S. hemphillii* is decidedly higher in proportion to length in comparison to that of *S. dolabriformis* Conrad (1178), the type of *Simomactra* Dall, which was originally described from Panama. The same characters separate it from *S. strongi* T.A. Burch (1179), which at times has been confused with Conrad's species. Differences in the hinges of these three species also exist. The right valve of *S. strongi* has only three lateral teeth whereas that of *S. hemphillii* and *S. dolabriformis* each has four such teeth. The right lower anterior lateral of *S. dolabriformis* is not in line with the anterior arm of the cardinal whereas the corresponding lateral of *S. hemphillii* is separated from but in line with the lateral.

Woodring (1180) mentioned that the fossil form occurring in strata of a Pliocene age in the Santa Maria district which he cited under the name of "*Spisula* cf. *S. hemphillii* Dall" is identical with the form described by Arnold (1181) as *Spisula sisquocensis*. According to Arnold this form "is near *S. hemphillii* Dall, but is constantly and decidedly narrower."

Macrothoma revellei Durham (1182) described from beds of Pleistocene age on Coronado Island in the Gulf of California, resembles *S. hemphillii* in the general outline but the Gulf fossil is "more truncate posteriorly across the gape and less rostrate anteriorly." Furthermore, the pallial

sinus of *S. hemphillii* is considerably narrower and is directed gently upward whereas the pallial sinus on the fossil from the Gulf of California is wider and is directed slightly downward.

The shell of *S. hemphillii* is decidedly more elongated anteriorly than is that of *S. catilliformis* and the pallial sinus is inclined upward rather than downward as it is in Conrad's species.

Spisula (Mactromeris) mercedensis Packard
Plate 54, Figure 12

Spisula mercedensis Packard, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 9, No. 15, p. 286, pl. 20 [not pl. 13 as cited], figs. 1a, 1b, May 1, 1916. — Keen and Bentson, Geol. Soc. Amer., Spec. Papers No. 56, p. 110, 1944. Original record cited.

Spisula (Hemimactra) mercedensis Packard, Glen, Univ. Calif. Publ. Geol. Sci., Vol. 36, No. 2, p. 175, 1959. Loc. B-4804, "In cliff along Highway 1, approximately 4,000 feet north of Franciscan - Merced contact at Mussel Rock. Fossils collected at road level from massive, grey to brown, medium-grained sandstone with a few highly fossiliferous interbeds", type Merced, Pliocene.

Type specimen. — No. 11467, University of California Department of Paleontology.

Type locality. — "in the marine cliffs of the Merced group, near Mussel Rock, San Mateo County, California." "Pliocene: Merced group."

Range. — Middle Pliocene.

Occurrence in San Diego Fm. — L.A.M. 107.

Original description. — Shell large, ventricose, inequilateral, the beaks being considerably anterior to the middle of the shell; anterior dorsal edge short, slightly concave, with a faint suggestion of a lunule; posterior dorsal edge gently convex, curving regularly to the rounded extremity; anterior end evenly rounded; base broadly arcuate; umbones small, sharply pointed; an indistinct posterior flexure extends from the umbones to the base, much as in *Spisula catilliformis* Conrad. Surface roughened by numerous irregular lines of growth. Hinge plate wide, chond[r]ophore shallow, wide, overhung but slightly by the posterior arm of the cardinal; left cardinal large, arms of equal length, high; anterior lateral short, situated dorsal to the anterior arm of the cardinal; posterior lateral high and acutely pointed. Hinge of the right valve unknown. Pallial sinus not observed. The dimensions of the type are: length 124 mm., height 93 mm., convexity 32 mm. (Packard.)

Remarks.—One specimen of a large elongate *Spisula* in the collection from Loc. 107 (LAM) retains considerable shell material. The left valve is 136 mm long and 93 mm high. The convexity (both valves together but somewhat overlapping) is 58 mm. The beak is approximately 62 mm from the anterior end.

The elongate outline, indistinct posterior flexure, and anteriorly placed beaks are all characteristics of *S. mercedensis*. The hinge is not visible, but according to Packard the anterior lateral is separated from the anterior arm of the cardinal on the left valve.

This species is evidently closely related to *S. cat-*

illiformis but the differences enumerated by Packard and those visible on the present specimen appear to justify recognition of this form as distinct from Conrad's species. This is the first record of *S. mercedensis* from strata other than those from the Merced Formation at the type locality and from southeast of Felt Lake in Santa Clara County.

Spisula (Mactromeris) cf. S. (M.) planulata Conrad
Plate 57 Figure 12

The following references, type locality, range and original description refer to typical *S. planulata*.

Mactra planulata Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 240, 1837.

Spisula falcata Gould, Packard, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 9, No. 15, pl. 26, figs. 1a, 1b, 1c, 1916. Recent.

Not *Mactra falcata* Gould, 1850.

Mactra (Spisula) planulata Conrad, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 397, 1931. Earlier records cited.

Spisula planulata Conrad, Morris, Field Guide to Shells of the Pacific Coast and Hawaii (Houghton Mifflin Co.: Boston), p. 56, pl. 15, fig. 6, 1952. Monterey, California, to Cape San Lucas, Mexico.

Type specimen. — Location unknown to present authors. [The type specimen could not be found in the Academy of Natural Sciences of Philadelphia, according to Dr. Robert Robertson (written comm., March 29, 1961).]

Type locality. — "Inhabits with the former" [that is, *Mactra californica* from "Inhabits muddy marshes, bare at low water, near Sta. Barbara; rare."]

Range. — Middle Pliocene to Recent. Recent from Monterey Bay, California, to Cape San Lucas, Lower California, Mexico (Dall), from intertidal zone to 91 meters (50 fathoms).

Occurrence in San Diego Fm. — L.A.M. 107. U.C.L.A. 294.

Original description. — Shell triangular, much compressed, subequilateral the posterior side rather shorter than the anterior; anterior side subcuneiform; posterior side with an obscure submarginal line, extremity rounded; beaks elevated; epidermis smooth, shining. Length, one inch and three-fourths. (Conrad.)

Remarks. — Two specimens in the present collections from near the Mexican boundary are provisionally referred to *Spisula planulata*. The largest one, the dorsal half of a right valve from Loc. 107 (LAM), is 74 mm long and 42 mm high. The beak is a little posterior to the middle of the valve. The lines of growth are comparable to the corresponding ones on Recent *S. planulata* of the same size. The other specimen is a small right valve, 30.8 mm long and 25 mm high, the ventral portion missing. It bears a decided resemblance to juvenile forms of *S. planulata* of the same size. The characters of the interior of these fossils is unknown and the identification is therefore not positive.

One of the largest Recent specimens of this species in the collection of the California Academy of Sciences, collected at San Diego by Henry Hemphill, is 68.8 mm

long, 50.6 mm high, convexity (both valves together) 25.2 mm the pallial sinus extends forward 30 mm from the posterior margin.

Spisula planulata has been confused with *S. falcata* Gould in the literature. It was not illustrated at the time of description by Conrad who stated that it was rare. The type specimen could not be found in the collections of the Academy of Natural Sciences at Philadelphia according to Dr. Robert Robertson of that institution. The results of a study of the literature and of specimens from various localities, especially from southern California, lead us to accept the interpretation of *S. planulata* given by Grant and Gale.

The shell of *S. planulata*, as recognized by us, is sub-trigonal (although this character varies with juvenile forms) and the right anterior accessory lamella is rather steeply inclined and offset from the ventral lateral by a comparatively wide, flat area on the hinge plate.

The shell of *S. falcata* Gould, originally described from Puget Sound is thinner, decidedly more inequilateral and more attenuated anteriorly than *S. planulata*, and the right anterior accessory lamina on the hinge is nearly in line with and only slightly separated from the ventral lateral.

The shell of the generally more southern species, *Spisula dolabriformis* Conrad is more attenuated anteriorly than that of *S. planulata*, the anterior dorsal margin beneath the beak is more projecting, on the adult shells there is a narrow radial depression anterior to the posterior angulation, and the pallial sinus is wider.

Spisula planulata, *S. falcata*, and *S. dolabriformis* appear to be related species and have been discussed by Burch (1183) and by Hertlein and Strong (1184). Many of the records of the occurrence of *S. planulata* in beds earlier than Pleistocene in age need confirmation.

Another member of this group of species is *Spisula strongi* Burch (1185) which was described from Newport Bay, California. Through the courtesy of Dr. Harald A. Rehder we were able to examine the type specimen of that species. It is 52.2 mm long, 34.6 mm high, convexity (both valves together) 17.3 mm, and the pallial sinus extends forward 22.2 mm from the posterior end of the shell. The outline of the shell is similar to that of *S. dolabriformis* of the same size. The hinge of *S. strongi* differs from that species, as mentioned by Burch, in that it lacks what he designates as a proximal anterior lateral tooth adjacent to the cardinal teeth and there is but one anterior lateral on the right valve.

The shell of *S. planulata* is more highly trigonal in outline than that of *S. strongi*. Furthermore, a proximal anterior lateral tooth is present on the hinge of the left valve and there are two well developed laterals on the right valve.

GENUS *TRESUS* GRAY

Cryptodon Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, P. 235, 1837. Sole species: "*L. nuttalli*" Conrad.

Not *Cryptodon* Turton, 1822, nor *Cryptodon* Latreille, 1833.

Tresus Gray, Ann. Mag. Nat. Hist., Ser. 2, Vol. 11, p. 42,

January, 1853. Sole species: "*T. maximus*." [Preceding the description of the genus, Gray mentions "*Lutraria* sp., Middendorff."] — Keen, Veliger, Vol. 4, No. 4, p. 179, 1962. "type species, by monotypy, *Lutraria maxima* Middendorff, 1849 [non Jonas, 1844] *L. nuttalli* Conrad, 1837" . . .

Not *Trésus* Walckenaer, Ann. Soc. Entomol. de France, Tome 2, p. 438, October, 1833. Arachnida. [No species cited. A virtual *nomen nudum*.]

Schizothaerus Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 6, p. 199, January, 1853 [issued February 7, 1853, according to A. M. Keen]. Sole species: *Schizothaerus nuttalli* Conrad. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 404, 1931. Type: *Schizothaerus nuttalli* Conrad.

Type species (by monotypy). — *Tresus maximus* [Middendorff] [= *Lutraria maxima* Middendorff, Beiträge zu einer Malacozoologia Rossica (from Mém. Sci. Nat. Acad. Imper. Sci. St. Petersbourg, Ser. 6, Vol. 6), Pt. III, p. 66, pl. 19, figs. 1-4, 1849. "Fundort: Die Insel Sitcha (Wosness.)" Not *Lutraria maxima* Jonas, 1844].

Range. — Middle Miocene to Recent: Recent from Japan to Lower California, from the intertidal zone to 46 meters (25 fathoms).

Original description. — Shell ovate, oblong, ventricose, hinder gape roundish; cardinal teeth small, lateral teeth very small, close to the cardinal; siphonal inflection large, oblong. (Gray.)

Remarks. — The generic name *Tresus* Gray apparently was published about a month earlier than *Schizothaerus* Conrad, as mentioned by Dall in 1909. However, Dall retained usage of the name *Schizothaerus* because of *Trésus* Walckenaer, 1833. Keen (1962) presented evidence to justify the replacement of *Schizothaerus* by *Tresus* Gray and this procedure has been generally accepted by authors.

Trésus Walckenaer was published in a key in a classification of arachnids. In this key it appeared with *Myrmecia* [Walckenaer, 1836], *Platiscelum* [Audouin, 1826], and *Attus* [Walckenaer, 1805] and a brief statement, "Voltigeuses. Sautant et voltigeant avec agilité pour attraper leur proie", applied to all four genera. *Trésus* is not mentioned elsewhere in the text and no species was assigned to it.

The usage of an accent mark does not indicate that name was used in a vernacular sense as believed by some workers. Such accent marks were used by others, for example, Gray (1186) mentioned "*Máctra grándis*", "*Spísula elongata*" and others.

Keen considers *Trésus* of Walckenaer to be a *nomen nudum* and it may be so interpreted because the particular descriptive material in the key applies to four genera. However, it would be desirable that the Internat. Comm. on Zool. Nomencl. Rule on the taxonomic status of Walckenaer's genus.

In view of the questionable taxonomic validity of *Trésus* Walckenaer we use *Tresus* Gray in the present paper.

The name *Schizothaerus* (1187) was applied to this genus by Conrad "In allusion to the profound channel which indents the hinge of both sides of the cardinal teeth." The general shape of the shell of this genus, oblong and gaping, is probably the result of the burrowing habit of the animal.

Two and perhaps three species are known to occur

in late Tertiary beds in western North America and one or two in Kamtschatka and Japan. Two Recent species are usually recognized in the fauna of western North America and one or possibly two in Japan and the North Pacific.

Tresus nuttallii Conrad

Plate 54, Figure 11; Plate 55, Figures 9, 13, 14, 17

L[utrar]ia. *Nuttallii* Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 235, pl. 18, fig. 1, 1837. (Under subgenus *Cryptodon*.)

Schizothaerus nuttallii Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 6, p. 199, 1853. — Packard, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 9, No. 15, p. 266 (in text), pl. 35, figs. 1a, 1b, 1916. Recent.—Packard, Univ. Calif. Publ. Zool., Vol. 14, No. 2, p. 283, pl. 28, figs. 1a, 1b, 1918. "Kodiak Island to Todos Santos Bay, Lower California."—I.S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 60, pl. 33, figs. 1a, 1b, 1924. "Wrangell, Alaska, to San Diego, Calif." Recent. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 196, pl. 31, figs. 1a, 1b, 1924. "Wrangell, Alaska, to San Diego, California. In the Pleistocene at Santa Barbara and San Diego, and the Pliocene at Santa Barbara, California."—Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 404, pl. 22, fig. 9; pl. 23, figs. 8a, 8b, 9, 1931. Late Miocene to Recent.—J.Q. Burch, Min. Conch. Club South. Calif., No. 44, p. 22, five figs. (on pp. 23-24), 1944. "Bollinas, Calif. to Scammon's Lagoon, Lower Calif." Recent.—Swan and Finucane, Nautilus, Vol. 66, No. 1, pp. 19-25, pl. 2, 1952. "extends at least as far north as 48°N." (p.23).—Fitch, State Calif. Dept. Fish Game, Mar. Fish Branch, Fish Bull. No. 90, p. 89, fig. 55, 1953. "Range: Puget Sound to Scammon's Lagoon, Baja California," Recent.

Tresus nuttalli Conrad, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 70, pls. 33, 34, 1968. San Diego region, Pleistocene. Also Miocene to Recent in California.

Type specimen. — Holotype No. 61.5.30.134, British Museum (Natural History) (A. M. Keen, Veliger, Vol. 8, No. 3, p. 170, 1966).

Type locality. — "Inhabits salt marshes, bare at low water, in the vicinity of Sta. Barbara." [California.]

Range. — Late Miocene (Briones Formation) to Recent. Recent, Wrangell, Alaska (Dall), to Scammon's Lagoon, Lower California, Mexico; in bays, estuaries, esteros and sheltered areas on the outer coast, from high tide line to 46 meters (25 fathoms).

Occurrence in the San Diego Fm. — C.A.S. Loc. 1402. L.A.M. Loc. 107, 305, 305A, 309. S.D. Loc. 408, 417. U.C.L.A. Loc. 1383, 2420.

Original description. — Shell elliptical, slightly gibbous from beak to base; posterior side produced; ligament margin slightly declining, rectilinear, extremity obliquely subtruncated; umbo prominent; colour white; epidermis very thin, brown, wrinkled on the margins. Length, six inches. (Conrad.)

Remarks. — *Tresus nuttallii* is represented in the collections from the San Diego Formation by a number of specimens, mostly single valves and hinges in various states of preservation. The largest specimen is a left valve

from Loc. 305 (LAM), near the Mexican Boundary. It is 150 mm long (posterior end incomplete) and approximately 112 mm high. A smaller specimen, both valves, from Loc. 2420 (UCLA), from Pacific Beach is 110.6 mm long, 74.6 mm high, convexity (both valves together, separated by about 3 mm) 51 mm. All the shell characters of these fossils are similar to those of Recent specimens from adjacent waters.

A large Recent specimen from Loc. 4649 (CAS), collected at San Diego, is 162 mm long, 98 mm high, convexity (both valves together) 71.5 mm; the pallial sinus extends forward and gently downward 94 mm from the posterior end of the shell. A huge Recent shell (1188) from Vaughan Bay, Washington, was reported to be 206 mm long and 139 mm high. This species also occurs elsewhere in Pliocene strata at various localities in California.

The shell of *Tresus nuttallii* is larger, longer, more ventricose, the anterior end is longer and the posterior gape is more rounded than that of *Tresus pajaroanus* Conrad (1189), a Pliocene species originally described from strata now considered to be referable to the Purisima Formation.

Three names for Recent West American species referable to *Tresus* were proposed subsequent to the description of *T. nuttallii*. *Lutrar]ia maxima* Middendorff 1849 (1190), (not *Lutrar]ia maxima* Jonas 1844), (1191), from Sitka, Alaska, is referable to *Lutrar]ia capax* Gould 1850, (1192) from Puget Sound and *Lutrar]ia inflata* Dunker 1853, (1193) described from California, believed to be a synonym of *T. nuttallii*.

Swan and Finucane (1194), made a careful study of *Tresus nuttallii*, also the rounded form, *T. capax*, which they considered to be a distinct species. They concluded that the adults of the rounded northern form are usually readily separable from *nuttallii*, that it usually burrows less deeply in more compact mud and gravel mixtures, that it withstands lower temperature, and that there are differences in the details of the animals of the two species. More recently Pearce (1195) also presented evidence to indicate that the two are separate species. Pholo (1196) described the changes of form and mode of life of *T. nuttallii*.

The name *Schizothaerus nuttallii bighopensis* was proposed by Henderson (1197) for a fossil form of Pleistocene age, from Big Hope Island in Puget Sound. This form, according to Henderson, differs from the rounded form described as *Lutrar]ia capax* by Gould in "being invariably thick, very coarse and rough, proportionately higher and the beaks more nearly central than in any recent material I have seen from there or elsewhere."

A species occurring in Japanese waters, often referred to *Schizothaerus nuttallii* was later described as *Schizothaerus keenae* by Kuroda and Habe (1198). The shell of the Japanese species is higher and the posterior truncation is broader than that of *T. nuttallii*. An extensive discussion of the habitat of this clam was published by Cahn (1199). A Miocene fossil in Japan, *Schizothaerus nuttallii kissyuensis* Hatai (1200), was described prior to *S. keenae* and the latter needs comparison with the fossil form.

ORDER ASTHENODONTIDA DALL
SUPERFAMILY MYACEA GOLDFUSS
FAMILY MYIDAE GOLDFUSS (1201)

Burrowers in sand or mud, sometimes nestlers, usually with elongated or ovate, subequal valves but often irregular or distorted in nestling forms, the surface white, earthy or chalky, often with coarse concentric growth sculpture and a covering periostracum. Ligament mostly internal; in the left valve, the resilium is attached to a large projecting arm or chondrophoral plate, the resilifer being a rounded or sagittate scar bordered above and behind by a small ridge (nymph); this chondrophoral arm fits into a deep pit in the beak of the right valve, the scar of the resilifer is placed in the roof of the umbone within, while above it on the posterior margin of the within, while above it on the posterior margin of the valve, there is a smaller scar to which the external portion of the ligament (tensilium) is attached. Hinge margin with or without teeth. Internal margins of valve smooth. Pallial sinus present or wanting. (Olsson, Mollusks of the Tropical Eastern Pacific. (Paleo. Res. Inst.: Ithaca, New York), p. 422, 1961.) Paleocene to Recent.

Remarks. — Four genera of the family Myidae are represented in the Pliocene of California, two of which occur in the San Diego Formation. In general, the members of this family live in shallow (low water to 50 meters, rarely to 265 meters), boreal and temperate waters where they burrow in muddy bottoms or nestle in cavities. Lamy (1203) published a revision of the members of this family represented in the collection of the Natural History Museum in Paris.

The genus *Mya* has not been reported from the San Diego Formation but it is represented from Miocene to Recent in strata along the northeastern Pacific. A subgenus *Antiguamya* Effinger (1204) was described from the Gries Ranch beds of early Oligocene age in western Washington.

A paper by Fujie (1205) contains an account of the genus *Mya* and its species in Japan. More recently, a paper by MacNeil (1206) contains a thorough discussion of the evolution and distribution of *Mya*.

Key to Genera of Myidae

- A. Pallial sinus large and broadly rounded *Sphenia*
B. Pallial sinus very short or lacking *Cryptomya*

GENUS *CRYPTOMYA* CONRAD

Cryptomya Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 4, p. 121, December, 1848. Sole species, *Sphaenia californica* Conrad. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 416, 1931. Type (bv monotypy): *Sphaenia californica* Conrad. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.:

Ithaca, New York), p. 423, 1961. Type by monotypy.

Type species (by monotypy). — *Sphaenia californica* Conrad.

Range. — Late Oligocene (San Ramon) or early Miocene, to Recent. Recent from the littoral zone to 91 meters (50 fathoms).

Description. — Shell small, ovate, slightly gaping posteriorly; similar to a small *Mya* from which it differs in that the pallial sinus is very short or lacking; chondrophore similar to that of *Mya arenaria*.

Remarks. — The shells of the species of this genus are somewhat variable in shape and this variability has led to the description of a number of species based upon rather slight differences.

Lamy (1207) discussed the Recent species of this genus in the collections of the National Museum of Natural History in Paris. Beets (1208) in 1950 cited ten species occurring as fossils, with the range of the genus from Miocene to Recent. There may be additional species, for his list lacks references to two fossil forms described in western North America, *Cryptomya incognita* Clark, from the San Ramon Formation, referred to late Oligocene age, and *C. quadrata vancouverensis* Clark and Arnold from the Sooke Formation, of late Oligocene or early Miocene age. In Japan and the East Indies this genus is known to occur from Miocene to Recent. Recent species have been reported from west Mexico to the East Indies and one species from the Red Sea and Australia. *Venatomya* Iredale (1209) was proposed as a genus with the Australian species, "type *Sphaenia elliptica* A. Adams."

Key to Species and Subspecies of *Cryptomya*

- A. Maximum length about 37 mm;
umbos usually gently inflated *californica*
B. Maximum length about 48 mm;
umbos usually moderately
inflated (subspecies) *magna*

Cryptomya californica Conrad
Plate 55, Figures 3, 4, 7, 16

S[phaenia]. californica Conrad, Jour. Acad. Nat. Sci. Philadelphia Vol. 7, Pt. 2, p. 234, pl. 17, fig. 11, 1837.
Cryptomya californica Conrad, Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 296, 1874. "Well at San Diego." "Pliocene.—Dall. Proc. U.S. Nat. Mus., Vol. 1, p. 28, 1878. Well at San Diego.—Cooper, Calif. State Min. Bur., Seventh Ann. Rept. State Mineral., p. 237, 1888. "Pl. — . . . San Diego well." — Orcutt, West Amer. Sci., Vol. 6, whole No. 46, p. 85, August 1889. Dall's record (1874) cited. — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 180, 1903. Cooper's record (1888) cited. — Orcutt, cited by Ellis and Lee, U.S.G.S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, Pt. 1, p. 48. Dall's record (1874) cited.—Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 423,

pl. 77, figs. 2, 2a, 1961. Alaska to Bayovar, Peru. *Mya (Cryptomya) californica* Conrad, Packard, Univ. Calif. Publ. Zool., Vol. 14 No. 2, p. 284, pl. 31, figs. 2a, 2b; pl. 53 (chart, distribution), 1918. Numerous localities in and near San Francisco Bay, California. "Range. — Chichagoff Island, Alaska to Topolobampo, Mexico (Dall)."

Type specimen. — Location unknown to the present authors.

Type locality. — "Inhabits salt marches, near Sta. Barbara; rare."

Range. — Late Miocene (Briones Formation) to Recent from Chichagoff Island, Alaska, to Bayovar, Peru. Along the beach in a zone just below *Heterodonax bimaculatus* Linnaeus (J.Q. Burch) (1210).

Occurrence in San Diego Fm. — San Diego well (Dall). L.A.M. Loc. 305.

Original description. — Shell suboval, convex-depressed, with radiating striae; obscure, except towards the posterior extremity, where they are distinct; posterior margin obliquely truncated, rectilinear; beaks central, ligament margin arcuate; tooth much dilated, oblique; colour white, pallial impression without a sinus, but forming a right angle posteriorly. (Conrad.)

Remarks. — *Cryptomya californica* was reported from the San Diego well by Dall in 1874. Apparently the later published records of the occurrence of this species in the San Diego Formation are based on that of Dall.

A number of valves here referred to *C. californica*, most of them fragmental, were collected by G. P. Kanakoff near the Mexican boundary. The largest one is a right valve, 16.2 mm long, and 13.3 mm high. Several valves are rather highly convex, probably as a result of the habitat.

Several small casts in the collections of the San Diego Society of Natural History lacking information as to the locality from which they came, might be referable to this species, but their small size and imperfect preservation are such that it is uncertain whether they should be referred to this species or to the subspecies *C. californica magna*.

The shell of this species is variable in outline and several other species described from the late Tertiary of western North America may be identical or at most subspecies of *Cryptomya californica*. A Recent specimen of average size from San Diego, collected by Frank Kelsey, is 31.8 mm long, 23 mm high, convexity (both valves together) 12.6 mm. A very large, somewhat quadrate specimen collected by Henry Hemphill at Tomales Bay, California, is 37 mm long, 29 mm high, convexity (both valves together) 15 mm. Grant and Gale placed six taxa in the synonymy of this species but we consider at least one of these, *C. magna*, to be a separate subspecies.

Cryptomya incognita Clark (1211) from the San Ramon Formation in Contra Costa Co., California appears to be a relative of *C. californica* but it is smaller and the chondrophore is said to differ in that there are two ridges bounding the resilium pit posteriorly rather than one.

Two other species of *Cryptomya* have been described from beds of Pliocene age in California and Oregon. *Cryptomya quadrata* Arnold (1212) was described as differing from *C. californica* by the more rectangularly truncated posterior end, less sloping dorsal margins and in

the greater size. *Cryptomya oregonensis* Dall (1213) was described as differing from *C. californica* by its subrhombic shape. Some authors have placed the Oregon species in the synonymy of *C. californica* but more recently Weaver (1214) treated it as a valid species.

Cryptomya californica occurs at the present time along western North America in shallow water both in sheltered bays and along the open coast. MacGintie (1215) mentioned that it may inhabit burrows of certain species of crabs to a depth of 51 cm (20 inches). J.Q. Burch mentioned that empty shells were dredged to depths of 18, 27, and 91 meters (10, 15, and 50 fathoms), and Yonge discussed the structure and adaptations of this species (Univ. Calif. Publ. Zool., Vol. 55, No. 6, pp. 395-400, figs. 1-4, 1951).

This species has been reported living in Japan but according to Habe (1216) the oriental species is referable to *Cryptomya busoensis* Yokoyama.

Cryptomya californica magna Dall

Plate 54, Figures 10, 13;

Plate 55, Figures 8, 10, 12

Cryptomya magna Dall, West Amer. Sci., Vol. 19, No. 2, p. 17, April 27, 1921.—Dall, Proc. U.S. Nat. Mus., Vol. 66, Art. 17, No. 2554, p. 15, pl. 13, figs. 3, 4, September 22, 1925. "Pliocene (?) of San Quintín Bay, Lower California." — Manager, Johns Hopkins Univ. Stud. Geol., No. 11, p. 293, 1934. San Quintín Bay, Lower California, Pleistocene.

Type specimen.—No. 333127, United States National Museum.

Type locality. — "San Quintín Bay, Lower California . . . late Pliocene or early Pleistocene . . ."

Range. — Middle Pliocene (San Diego Formation); Pleistocene (San Quintín Bay), Lower California, Mexico.

Occurrence in San Diego Fm. — C.A.S. Loc. 1402. L.A.M. Loc. 305, 305A, 319. S.D. Loc. 29. U.C.L.A. Loc. 312, (cf) 1386.

Original description. — Shell oval, inflated, thin, nearly equilateral and equivalve, sculptured only with rather prominent incremental lines; beaks low, nearly central, posterior end very slightly more attenuated than the anterior end; hinge with a very large receptacle for the ligament with a strong ridge at the anterior and posterior edges; a small anterior lateral in the left valve, right valve edentulous; posterior muscular scars larger than the anterior; pallial sinus almost obsolete. Length 35; height 24; diameter 17 mm. (Dall.)

Remarks. — Several well preserved specimens from Balboa Park in San Diego agree in shape and size with the form described by Dall as *Cryptomya magna*. The only feature mentioned in his original description which we have not observed on the present fossils is an anterior lateral tooth on the left valve. However, this is not shown on his illustration of the type. We have examined specimens of a *Cryptomya* from the type locality and we have not observed any distinct anterior lateral on any of the left valves.

The present fossils from the San Diego Formation are much larger and more elongate than Recent specimens of *Cryptomya californica*. The largest specimen we have ob-

served is a right valve from Loc. 29 (SD), Balboa Park, San Diego, 48 mm long, 35.8 mm high (incomplete), convexity (one valve) 9.4 mm. Nearly all the specimens from Balboa Park attain a length between 40 and 45 mm. The size and shape of these fossils differ from those of Recent *Cryptomya californica* sufficiently to justify subspecific status for Dall's *Cryptomya magna*.

One cast from Reynard Way in the collections of the San Diego Society of Natural History appears to be referable to this subspecies. Several small casts in the collections of the same institution which lack information as to the locality from which they came may perhaps be referable to this form.

This is the first record of the occurrence of this large subspecies from a locality other than the type locality in beds of Pleistocene age at San Quintin Bay, Lower California.

GENUS SPHENIA TURTON

Sphenia Turton, Conchyl. Insul. Britannicum, pp. XVII, 36, 1822. Species cited, *Sphenia binghami* [Turton], *S. swainsoni* Turton, *S. decussata* [Montagu]. — Cossmann and Peyrot, Act. Soc. Linn. Bordeaux, Tome 63 (Conch. Néog. L'Aquitaine, Tome 1), p. 87, 1909. "G. - T.: *S. Binghami* Turton." — Lamy, Jour. de Conchyl., Vol. 70, No. 3, p. 176, 1927. "dont le type est *S. binghami* Turton." — Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 149, 1953. "Type by subsequent designation, Gray, 1847: *S. binghami* Turton."

"*Spaena* Turton" and "*Sphaenia* Turton" of authors.

Type species (by subsequent designation, Gray, Proc. Zool. Soc. London for 1847, p. 190). — "*Sp. Binghami*" [Turton, Conchyl. Insul. Brit., p. 361, pl. 3, figs. 4, 4; pl. 19, figs. 3, 1822. "Rocks in Torbay." Also illustrated by H. and A. Adams, Gen. Rec. Moll., Vol. 2, p. 357, 1856, pl. 95, figs. 4, 4a, 4b, 1855. — Tryon, Struct. and Syst. Conch., Vol. 3, pl. 105, fig. 96, 1884. Europe. — Lamy, Jour. de Conchyl., Vol. 70, No. 3, p. 178, two figs. (p. 176), 1927. For a discussion of this species see Yonge, C. M., "Observations on *Sphenia binghami*," Jour. Mar. Biol. Assoc. U.K., Vol. 30, No. 3, pp. 387-392, 2 figs. in text, 1951.]

Range. — Paleocene to Recent. Recent, widespread, from intertidal zone to 393 meters (215 fathoms), most abundant in cool and temperate waters.

Description. — Shell generally small, inequivalve, elongate, usually irregular because of a nestling habit. External surface marked only with irregular growth-lines sometimes divided into resting stages. Hinge teeth absent. Left valve with an elongate, flattened chondrophore which extends or fits obliquely under the umbonal margin of the right valve. Pallial sinus large and broadly rounded. (Olsson and Harbison.)

Remarks. — Three species attributed to this genus (one doubtfully) have been reported from strata of Tertiary age in California. Five species are reported to be living in waters between Alaska and San Diego, California, and at least three species have been described from tropical west American waters.

The genus *Sphenia* is reported here for the first

time from the San Diego Formation. One species, *Sphenia* cf. *S. globula* Dall was reported by Woodring from the Foxen Mudstone of Pliocene age in the Santa Maria district in Santa Barbara Co.

E. A. Smith (1217) discussed the genus *Sphenia* in which he included ten Recent species. Lamy, 1927, also discussed this group of pelecypods.

Sphenia cf. *S. luticola* Valenciennes

Plate 56, Figures 21, 22

The following are references to typical *S. luticola*. *Corbula luticola* Valenciennes, Zool. Voy. Venus, Atlas, Moll., pl. 24, figs. 6, 6a, 1846 [No locality cited.] *Sphaenia fragilis* Carpenter, Cat. Mazatlan Shells Brit. Mus., p. 24, August, 1855. — Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 543, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, p. 29, 1872. — Brann, Illustrations to "Catalogue of the Collection of Mazatlan Shells" by Philip P. Carpenter (Paleo. Rest. Inst.: Ithaca, New York), p. 12, pl. 5, fig. 35; pl. 6, fig. 35, 1966. — Keen, Veliger, Vol. 10, No. 4, p. 400, text fig. 22, 1968.

Sphenia fragilis Carpenter, de Folin, Les Méléagrini-coles (Havre), p. 15, pl. 2, figs. 7, 9, 1867. — E. A. Smith Ann. Mag. Nat. Hist., Ser. 6, Vol. 12, p. 279, pl. 15A, figs. 4, 5, 1893. "Hab. Mazatlan, west coast of Mexico." — Lamy, Jour. de Conchyl., Vol. 70, No. 3, p. 179, 1927. "Californie." — K.V.W. Palmer, Geol. Soc. Ame., Mem. 76, p. 116, 1958. Earlier records of range cited. — Franc, Traité de Zool., Vol. 5, Fasc. 2, p. 2150, fig. 1801 E (p. 2121), 1960. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 424, pl. 77, figs. 9, 9a, 9b, 1961. "Venado Beach, Panama Canal Zone." Range: "Oregon? to Northern Peru."

Type specimen of *Corbula luticola*. — Muséum Nationale d'Histoire Naturelle, Paris. Type material of *Sphenia fragilis* is also in the British Museum (Natural History) (see Lamy, 1927, p. 180).

Type locality. — No locality originally cited for *Corbula luticola*. Of *Sphenia fragilis*, "Hab. — Mazatlan: inhabiting the burrows of worms and Mollusks in Chamae and *Spondylus Lamarckii*; also in dead Balani on *Strombus galea*; not uncommon; L'pool & Havre coll."

Range. — Oregon?; California to Zorritos, Peru. Occurrence in San Diego Fm. — L.A.M. Loc. 305.

Original description of *Sphenia fragilis*. — *S. animalis* in cryptis latibulante, ergo ovarie distorto; testâ parvâ, tenui, subnacreâ, vix rugose striatâ; epidermide fusco-virente copiose indutâ, regarum increscentium concentricarum plenâ, postice in siphone longâ porrectâ: parte posticâ plus minusva subcarinatâ; valvâ sinistrâ dente ligamentum ferente, plus minusve seu prolongatâ seu extanta; dextra alveo conveniente, nonnunquam denticulo subextante: impressionibus muscularibus subrotundatis, sinu pallii lato, rotundato, haud alto. (Carpenter.)

Largest specimen, Long. .18, Lat. .31, alt. .14 inches (Carpenter).

Remarks. — One left valve of a *Sphenia* about 4 mm long, was collected by George P. Kanakoff at Loc. 305 (LAM) near the Mexican boundary. A study of this

specimen leads us to refer it provisionally to *Sphenia luticola*.

Carpenter in 1864 mentioned that his "*Sphaenia fragilis* is perhaps *S. luticola*, Val." Lamy, in 1927, stated that an examination of two "specimens-types" of *Corbula luticola* Valenciennes, 1846, confirmed Carpenter's suggestion that *S. fragilis* is identical with the species described by Valenciennes.

Sphenia pacificensis de Folin (1218) is believed by Keen (1219) to be only a more elongate form of *S. fragilis* from Panama.

Olsson (1961, p. 423) mentioned that specimens in the U. S. National Museum from Oregon and California which are labelled *Sphenia fragilis* are much larger than specimens of *S. fragilis* from the Panamic region. He suggested that the northern shells may be referable to *S. trunculus* Dall (1220) which is probably only a large form of *S. fragilis*.

SUPERFAMILY CORBULACEA BOWDICH (1221)

FAMILY CORBULIDAE BOWDICH (1222)

The shell is small or medium size, rarely large, elongately ovate, usually solid, the beaks generally submedian, the anterior side rounded, the posterior side rostrated and pointed at the end. The right valve is usually larger and with stronger sculpture, the left valve may be similar, or much smaller, with a more rounded outline, its surface flat or depressed, and with finer or smoother sculpture. The ligament is entirely internal, attached to an armlike resilifer in the left valve, simulating a large tooth, which fits into a deep socket-like resilifer in the right valve. Hinge armature is variable but most *Corbula*s have a single, large, hooked cardinal tooth in the right valve placed in front of the resilial pit; there is a single cardinal socket in the left valve; lateral teeth are absent in most groups. The pallial line is entire or it may carry a small obscure posterior sinus. Surface covered with a periostracum, sometimes heavy. [Olsson, *Mollusks of the Tropical Eastern Pacific* (Paleo. Res. Inst.: Ithaca, New York), p. 426, 1961.] Triassic to Recent.

Remarks. — A number of genera and subgenera of this family have been described. A satisfactory assignment of some of the species to the known supraspecific units often offers difficulties.

Papers by Gardner (1223) and by Vokes (1224) are an aid to anyone dealing with the Corbulidae. A catalogue of the Recent species in the collections of the Natural History Museum in Paris was published by Lamy (1225).

GENUS CORBULA BRUGUIÈRE

[*Corbula* Bruguière, Tabl. Encyclop. Méth. Vers Test., Vol. 2, pl. 230, 1797. [Illustrations with genus name only, no text or specific names.] — Lamarck, Syst. Anim. s. Vert., p. 137, 1801. Species cited: *Corbula sulcata*, *C. laevigata*, *C. margaritacea*, *C. gallica*, *C. striata*. — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 286, 1930. Type species as designated by

Schmidt, 1818, *Corbula sulcata* Lamarck.—Vokes, Bull. Amer. Mus. Nat. Hist., Vol. 86, Art. 1, p. 7, 1945. Type designated by Schmidt, 1818.—Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 145, 1953. Type designated by Schmidt, 1818.

Not *Corbula* Röding in Bolten, Mus. Bolt., p. 184, 1798. [= *Asaphis* Modeer, 1793.]

Aloidis Megerle von Mühlfeld, Ge. Naturfor. Freunde zu Berlin, Vol. 5, p. 67, 1811. Species cited: *Aloidis guineensis*. Ref. to "Linn. Syst. Nat. pag. 3287" and "Chemn. Conch. 10.t.172.f.1670. 1671." — Hertlein and Strong, Zoologica, Vol. 35, Pt. 4, p. 236, 1950. "Type (by monotypy): *Aloidis guineensis* Megerle von Mühlfeld." [= *Corbula sulcata* Lamarck.]

Type species (designated by Schmidt, Versuch Conch.-Samml., p. 77, 1818): — "Typ. *Corbula sulcata*. Encyclop. tab. 230. Fig. 1. a. b. c." [Lamarck, Syst. Anim. s. Vert., p. 137, 1801. No locality cited. — Lamarck, Hist. Nat. Anim. s. Vert., Vol. 5, p. 495, 1818. "Habite. . . l'Océan indien?" — Illustrated by Reeve, Conch. Icon., Vol. 2, *Corbula*, sp. 2, pl. 1, fig. 2, 1843. "Hab. Senegal." — Vokes, 1945, p. 7 et seq., pl. 1, figs. 1-5. Senegal, Recent.]

Range. — Triassic?; Jurassic to Recent. Recent from the intertidal zone to 2699 meters (1476 fathoms).

Description. — Shell inequilateral, inequivalve, the right valve somewhat larger than the left, which it clasps or overlaps along the ventral margin, solid, rostrated. Right valve has a large anterior cardinal tooth in front of a deep resilial pit and a smaller posterior lateral tooth. Left valve carries a heavy hinge plate bearing a large, deep cardinal socket, a smaller pit for the resilium behind it (not a separate chondrophore plate), a rather large, knob-like posterior cardinal, and a small posterior lateral socket. Sculpture of both valves of strong concentric riblets. Both valves have a prominent umbo ending in an incurved beak, narrowly rostrated or pointed behind, the rostral area forming a depressed or concave escutcheon-like zone, bounded externally by an angle or keel running from the beak to the posterior extremity of the shell. (Olsson and Harbison.)

Remarks. — The use here of the genus name *Corbula* is based upon the ruling of the Internat. Comm. Zool. Nomencl. in 1950. In that ruling (1226) it was stated that a genus name appearing on a plate but without explanatory matter is to be considered as published if it appeared prior to January, 1931. This is not a very satisfactory solution because it leaves open to personal opinion the identification of the species represented by unidentified figures. The ruling, however, appears to be clearly applicable to the name *Corbula*. If for any reason the name *Corbula* should be abandoned, *Aloidis* Megerle von Mühlfeld would take its place.

Eames (1227) discussed the genus *Corbula* and considered Gray's (1228) designation of *Corbula sulcata* to be the first valid designation of type species of this genus rather than that of Schmidt because the type designation by the latter refers to *Corbula* of Lamarck. However, most authors accept Schmidt's earlier designation of the same species as the type of *Corbula*.

There are between 75 to 100 Recent species which have been assigned to *Corbula* or to subgenera allied to it. These live in sand or mud in warm, often shallow waters along the seashore or in estuaries although species have

been reported from depths exceeding 2000 meters. Most of the species do not exceed 10 mm in length but some attain a length of 30 mm or more.

SUBGENUS *VARICORBULA* GRANT AND GALE

Varicorbula Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, pp. 12, 420, November 3, 1931.—Vokes, Bull. Amer. Mus. Nat. Hist., Vol. 86, Art. 1, p. 12, 1945. Type designation by Grant and Gale cited.—Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 147, 1953. "Type by original designation: *Corbula gibba* (Oliv)."—Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 438, 1961. Type as in preceding reference.

Type species (by original designation). — "In case a new name is needed for the *gibba* group, we propose *Varicorbula*, with *Corbula gibba* (Oliv) as figured by Bucquoy, Dautzenberg and Dollfus for the type." [See Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. du Roussillon, Tome 2, Fasc. 11 (Pelecypoda, Fasc. 24), p. 578, pl. 85, figs. 1-6 (typical), 7-23 (varieties), 1896. Mediterranean, Adriatic, Sea of Marmora; Atlantic Ocean from Norway to the Canary Islands, Also Miocene to Recent.—Vokes, 1945, p. 8, pl. 1, figs. 11-15. "Recent. Zetland, British Isles."—Tebble, British Bivalve Seashells [British Museum (Nat. Hist.)], p. 171, text fig. 91a, b, c, 1966.]

Range.—Late Cretaceous (Maestrichtian) to Recent. Recent from the intertidal zone to 2697 meters (1476 fathoms).

Description. — Shell small or of medium size, subrounded and with strongly discrepant valves as to size and sculpture. Right valve larger, higher, more convex, obtusely rostrated and slightly produced posteriorly, generally sculptured with strong, concentric riblets. Left valve smaller, flatter, subelliptical in form, its surface smoother, and bearing a few irregularly distributed radial threadlets on its ventral portion. Hinge: right valve, as in other *Corbula*s, has a single large cardinal tooth in front of a deep resilial pit; left valve with a small projecting chondrophore, its inner portion carrying a resilial scar, bounded behind by an elevated lamella which may function as a substitute tooth, and which fits into a small depression along the posterior side of the resilial pit of the opposite valve. (Olsson and Harbison.)

Remarks. — The shell of *Varicorbula* differs from that of typical *Corbula* in the very fine sculpture on the left valve which also often bears some irregularly spaced radial threads on the ventral portion. Also the left valve has a small, projecting chondrophore, a feature lacking on the type species of *Corbula*.

Vokes, 1945, gave *Varicorbula* generic status and placed it in a new subfamily, Caryocorbulinae, and this was followed later by several authors. We follow the more conservative course by treating it as a subgenus of *Corbula*, at least until the systematics of the family Corbulidae is more stabilized.

The similarity of *Varicorbula* to *Notocorbula* Iredale (1229) was mentioned by Woodring (1230) and later by Eames both of whom suggested possible relega-

tion of it to the synonymy of Iredale's genus. The type species of *Notocorbula* has a well developed rostrum posteriorly and the cardinal tooth was described as keeled. Vokes accepted *Notocorbula* as a valid genus but did not suggest any close relationship to *Varicorbula*.

Yonge (1231) discussed the habits and adaptations of the European species *Corbula gibba*, the type of *Varicorbula*. The development of sculpture of inequivalve mollusks, including *Corbula* was discussed by McLean (1232).

Corbula (Varicorbula) gibbiformis Grant and Gale Plate 57, Figures 3, 4

Corbula (Corbula) gibbiformis Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 420, pl. 19, figs. 4, 5, 6, November 3, 1931.

Corbula (Varicorbula) gibbiformis Grant and Gale, Woodring, U. S. G. S., Prof. Paper 190, p. 55, pl. 6, figs. 8, 9, 1938. "Great American Petroleum Co. Tuffree No. 2, East Coyote field, depth 3,351 to 3,356 feet; U. S. G. S. locality 13873." — Woodring, et al., in Winterer and Durham, U. S. G. S., Prof. Paper 334-H, p. 304, 1962. Pico Formation, north and south side of Santa Clara River Valley.

Corbula gibbiformis Grant and Gale, Vedder, U. S. G. S., Prof. Paper 400-B, p. B327, 1960. "Niguel formation," also "Eastern Ventura basin."

Type specimen. — No. 172, San Diego Society of Natural History.

Type locality. — "Southern California Gas Company's well No. 1-4, Sec. 4, T. 28 S., R. 23 E., Kern County, depth 3951-2 feet, upper Etchegoin formation, upper Pliocene."

Range. — Middle Pliocene.

Occurrence in San Diego Fm. — U.C.L.A. Loc. 2359.

Original description. — Shell of medium size, trigonal, plump; right valve strongly ventricose, with strong, concentric, closely-spaced riblets, left valve smaller, more elongate, with about five low, narrow, sharp radial riblets; right hinge with one strong cardinal tooth beneath the curved-over umbo and anterior to a prominent pit; left valve with a pit and a low, tooth-like prominence posterior to it. Length, about 13 mm.; height, about 13 mm. (Grant and Gale.)

Remarks. — Six specimens, mostly small, are present in the collection from Loc. 2359 (UCLA). The largest specimen, a right valve, is 14.9 mm long, 14.6 mm high, convexity, 7.3 mm. All of these specimens have lost some of the outer layer of the shell as a result of erosion. Concentric sculpture is visible on some portions of larger specimens and faint radial sculpture is visible on some of the left valves. The hinge of the right valve bears a small tooth similar to that shown in the figure of the paratype (fig. 4) by Grant and Gale. The fossils from the San Diego Formation appear quite similar to the illustrations of *C. gibbiformis* published by Woodring. The state of preservation of the specimens is imperfect but their close resemblance to *C. gibbiformis* leads us to refer them to that species. Specimens comparable to *C. gibbiformis* were recorded by Stewart (1233) from the *Pecten* zone of the

San Joaquin Formation in the San Joaquin Valley.

Corbula gibbiformis bears considerable resemblance to *C. speciosa* Reeve (1234), a tropical west American species, but the Pliocene species apparently has more regular, finer, concentric sculpture and a smaller tooth in the hinge of the right valve. Furthermore, the fossils lack the subquadrate shell development (nepioconch) which forms the umbo of the right valve of *C. speciosa* for a distance of about 5 mm and then changes abruptly to coarse rugose concentric sculpture. This early shell development on *C. speciosa* has much the appearance of *C. marmorata* Hinds.

Corbula nuciformis Sowerby (1235), another inhabitant of tropical west American waters, resembles *C. gibbiformis* in general outline but it is smaller, possesses finer concentric sculpture and lacks radial sculpture on the left valve. The same characters serve to separate *C. gibbiformis* from *C. granti* Olsson (1236), described from Pliocene beds in Costa Rica.

Another species cited by Olsson (1237) as "*Corbula* (*Varicorbula*) cf. *bradleyi* Nelson" from beds of Pliocene age in Panama, was said to differ from *C. gibbiformis* in the less elevated form.

SUBGENUS *LENTIDIUM* CRISTOFORI AND JAN

Lentidium Cristofori and Jan, Catalogus, Section II^a, Conchyliologia, Pars 1^a, p. 8; Mantissa, p. 4, 1832. Sole species: *Lentidium* "*maculatum* nob." "*Ital. bor.*" —Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 836, also 838, 1898. "*Type Corbula mediterranea* Costa (+ *maculatum* Jan.)." —Vokes, Bull. Amer. Mus. Nat. Hist., Vol. 86, Art. 1, p. 23, 1945. Type designation by Dall cited.

Corbulomya Nyst, Mém. Cour., Acad. Roy. Sci. de Belgique, Vol. 17, p. 59, 1844. Type (designated by Hermannsen, Indic. Gen. Malacozoo., Vol. 1, p. 308, 1847): "*Typus: Corbula complanata* Sow." —Cossmann and Peyrot, Act. Soc. Linn. Bordeaux, Tom. 63 (Conch. Néogén. l'Acquitaine, Tome 1, Livr. 1), p. 109, 1909. Designation of type species by Hermannsen cited.—See also Vokes, 1945, pp. 23, 24, 26.

Type species (by monotypy). — *Lentidium maculatum* Cristofori and Jan. [Original description (Mantissa, p. 4): *L.* tests planata, striata, alba, maculis croceis picta (lat. 2" long. 1 1/2").] Considered by Monterosato (Nom. Gen. Spec. Conch. Mediterr., p. 30, 1884) and by Dall, 1898, to be referable to *Tellina mediterranea* O. G. Costa (Cat. Test. Sicilie, p. XIV, pl. 1, fig. 6a, b, c, 1829). Mediterranean, Recent. See *Corbulomya mediterranea* Costa, Bucquoy, Dautzenberg, and Dollfus Moll. Mar. Roussillon, Tome 2, Fasc. 11 (Pelecypoda, Fasc. 24), p. 585, pl. 85, figs. 24-29 (typical), 30-35 (varieties), 1896. For a thorough diagnosis of *Lentidium mediterranea*, see Vokes, 1945, pp. 23-24, pl. 4, figs. 23-27, 1945. "Recent. Genoa. Italy."]

Range. — Early Eocene (Thanetian) to Recent.

Original description of *Lentidium*. — "Testa compressiuscula subtriangularis, valvulis inaequalibus. Cardo dente unico in utraque valvula, simplici in dextra, plicato in sinistra. Liagmentum partim internum." (Cristofori and Jan, 1832, Mantissa, p. 4.)

Supplementary description. — Shell compressed, trapezoid, feebly concentrically sculptured; the ligament appearing externally through a fissure in the right umbo. (Dall, 1898.)

Remarks. — The sole species listed under *Lentidium* by Cristofori and Jan is *L. maculatum* although a number of authors have cited *Corbula mediterranea* Costa [= *Tellina mediterranea* O.G. Costa, 1829] as the type. It appears probable that the species described by Costa is identical with the one described only briefly by Cristofori and Jan as indicated by Monterosato and by Dall. Bucquoy, Dautzenberg and Dollfus, however, did not include *L. maculatum* in their synonymy of *Corbulomya mediterranea* Costa.

Cossmann and Peyrot considered *Corbulomya* Nyst, to be at least subgenerically distinct from *Lentidium*. Most modern authors consider the two referable to the same genus or subgenus and we follow that practice in the present paper.

Vokes placed *Lentidium* as a genus in a new subfamily Lentidiinae.

Corbula (*Lentidium*) *luteola* Carpenter Plate 55, Figures 1, 2, 5, 6, 15

Corbula luteola Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 661, 637, issued August, 1864. P. 611, "S. Pedro-S. Diego; common near shore." P. 637, indicated as from "The region between S. Diego and S. Pedro." Reprint in Smithsonian Misc. Coll., No. 252, pp. 97, 123, 1872. — Carpenter, Proc. Calif. Acad. Sci., Vol. 3, Pt. 3, p. 207, February, 1865. "Hab. — San Diego, San Pedro, 50 alive at low water." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 203, 1924. "Monterey, California to Lower California." Recent. Also Pleistocene at San Pedro and San Diego, and Pliocene at San Pedro, California.

Corbula luteola var. *rosea* Williamson, Bull. South. Calif. Acad. Sci., Vol. 4, No. 8, p. 120, November, 1905.

"Valve on anemone in a rock pool on the old breakwater at Terminal Island," San Pedro, California. Not *Corbula rosea* Reeve, Conch. Icon., Vol. 2, *Corbula*, species 26, pl. 4, fig. 26, April 1844. "Hab. — ?"

Corbula (*Lentidium*) *luteola* Carpenter, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 421, pl. 19, figs. 2, 7, 1931. Various localities cited. Late Miocene to Recent.—Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 94, pl. 25, figs. 15, 16, 1950. Santa Ynez Bay, Lower California, Pleistocene.—K.V.W. Palmer, Geol. Soc. Amer., Mem. 76, p. 117, pl. 15, figs. 13-18, 1958. [Earlier records cited. Type specimens discussed.]

Alodis (*Caryocorbula*) *luteola* Carpenter, Hertlein and Strong, Zoologica, Vol. 35, Pt. 4, p. 239, 1950. Monterey, California, to Cape San Lucas, Lower California.

Corbula (*Caryocorbula*) *luteola* Carpenter, Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, Calif.) p. 209, fig. 525, 1958. Southern California to La Paz, Lower California, Mexico.

Type specimen. — "Syntypes.—U. S. National Museum, no. 14897 (eight valves)." (Palmer, 1958.)

Type locality. — "Recent. San Pedro, California (type)." (Palmer, 1958.)

Range. — Late Miocene to Recent. Recent from Monterey, California, to La Paz Lower California, Mexico, from between tides to 46 meters (25 fathoms). Usually in rocky rubble according to J. Q. Burch (Min. Conch. Club South. Calif., No. 44, p. 29, February, 1945).

Occurrence in San Diego Fm. — L.A.M. Loc. 302, 305, 305A, 318, 319.

Original description. — "Shape of young *biradiata*; small, ashy yellow. Com. Cp." (Carpenter, 1864.)

Supplementary description. — C. t. "*C. biradiatae*", formâ simulante, sed multo minore; haud obesâ, transversâ, luteo-conereâ, dorsum versum interdum obscure biradiatâ; angulo plus minusve carinato, postice definito; antice rotundatâ, expansa; concentrice crebree sed obtuse lirulatâ; umbonibus obtusis; intus, dentibus minoribus; linea pallii angulatâ, haud sinuatâ; cicatricibus adductoribus callosis; margine t. adultâ postice altero alterum amplectante. (Carpenter, 1865.)

Remarks. — *Corbula luteola* is here reported for the first time from the San Diego Formation. There are about 40 single valves and one specimen with paired valves from Loc. 305 (LAM) near the Mexican boundary. The largest valve is 9 mm long and 5.7 mm high. The specimen with both valves together is 8.1 mm long, 5.3 mm high, the convexity (both valves together) 3.5 mm. A large Recent specimen collected by Henry Hemphill at San Diego is 10.5 mm long, 7.2 mm high, the convexity (both valves together) 4.3 mm, but most Recent specimens are smaller than this one. A few single valves are present in the collections from Loc. 305A, 318 and 319 (LAM).

Corbula luteola has been compared with *C. biradiata* Sowerby (1238) by several authors. Carpenter's species is smaller, generally more compressed, the posterior ventral margin less acutely pointed and the coloration is dull gray or buff.

SUPERFAMILY HIATELLACEA GRAY
FAMILY HIATELLIDAE GRAY (1239)
[SAXICAVIDAE GRAY]

Shell usually ovate or oblong, generally irregular due to distortion, widely gaping behind, byssiferous. Surface smooth but more often with irregular concentric riblets or undulations. Hinge weak, the teeth often obsolete, no laterals, the ligament external, attached to a strong nymphal ridge. Pallial sinus of irregular size, the animal provided with large siphons. Burrowing in deep sand, gravel, or as nestlers or borers in rock. [Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York) p. 425, 1961.] [Late Jurassic to Recent.]

Remarks. — The shells of this family vary greatly in size. The animals are burrowing or nestling forms and, reflecting this habitat, their valves are gaping. There are two small simple teeth in the hinge of the left valve and one in the right. Their shells are usually sculptured only with rude concentric ridges on the shell surface. Members of this family often occur in the intertidal zone but some have been reported to a depth of 448 meters. Kühnelt (1240) discussed the habitat of this group of mollusks and White (1241) described the anatomy of "*Saxicava*" *gallicana* Lamarek.

A list of the species by Tryon (1242) and a revision of the members of this family by Lamy (1243) are useful

in a study of this group.

Key to Genera of Hiatellidae

- A. Shell with pallial line broken into an irregular series of impressions.
 - a. Shell with a median radial depression; roundly subquadrate, nearly as high as long *Panomya*
 - aa. Shell lacking a median radial depression; rectangular, decidedly longer than high *Hiatella*
- B. Shell with pallial line entire;
 - very large *Panope*

GENUS HIATELLA DAUDIN

Hiatella Daudin in Bosc, Hist. Nat. des Coquilles, Vol. 13, AN X [1801], p. 120. [This volume appeared prior to October 23, 1801, according to Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100 Art. 1, p. 33, 1952.] Species cited: *Hiatella biaperta* and *Hiatella monoperta*. — Iredale, Rec. Austral. Mus., Vol. 17, No. 9, p. 406, 1930. — Davies, Tert. Faunas (Thomas Murby and Co.: London), Vol. 1, p. 201, figs. 169, 270, 1935. Paleocene to Recent. Widespread. — Dodge, Nautilus, Vol. 64, No. 1, pp. 29-33, July, 1950. "The type of the genus may be cited safely as *H. biaperta* Daudin + *H. monoperta* Daudin, = *Mya arctica* Linné, by subjective monotypy." — Hertlein and Strong, Zoologica, Vol. 35, Pt. 4, p. 244, December 30, 1950. "Type (here designated): *Hiatella biaperta* Bosc."

Saxicava Fleuryau-Bellevue, Jour. de Physique de Chemie d'Hist. Nat. et des Arts, Tome 54, AN X, p. 354, May 1802. Species cited: "La saxicave striée, *saxicava striata*." "Perec les rochers des côtes de la Rochelle." — Lamy, Jour. de Conchyl., Vol. 68, No. 3, p. 218, 1924. "qui a pour type *S. striata* Fl. = *Mya arctica* L."

Didonta Schumacher, Essai Nouv. Syst. Test., pp. 42, 125, 1817. Species cited: *Didonta bicarinata* Schumacher, p. 125, pl. 6, fig. 2. Ref. to *Solen minutus* Linnaeus, Chemnitz, Neues Syst. Conchyl.-Cab., Bd. 6, p. 67, Tab. 6, figs. 51, 52, 1782. [= *Mya arctica* Linnaeus.]

Type species (by subsequent designation, Dodge, 1950, p. 31, and Hertlein and Strong, 1950, p. 244). — *Hiatella biaperta* Daudin in Bosc, Hist. Nat. des Coq., Vol. 3 AN X [1801], p. 120, pl. 21, fig. 2. "Se trouve sur la cote de Tranquebar." [= *Mya arctica* Linnaeus.]

Range. — Paleocene to Recent. Recent world-wide, chiefly in cool waters, from the intertidal zone to 2966 meters (1622 fathoms) usually burrowing or nestling in cavities.

Description. — Shell small, irregular, very inequilateral, the young with a cardinal tooth like *Panomya*, the adult with the teeth obsolete; pallial line discontinuous, siphons naked, slightly separated at the tips and in normal

specimens completely retractile, shell burrowing, or nestling in gravel or broken shell, or perforating rocks, corallines, or dead shells like pholads. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 833, 1898.)

Remarks.—This genus has been reported occurring from Paleocene to Recent. Whether or not it occurs in older strata is not certainly known but the genus has been cited, doubtfully, from strata of late Cretaceous age, in Alberta, Canada (1244). *Pseudosaxicava* Chavan (1245) described from beds of late Jurassic age in France is believed to be an ancient member of the Hiatellidae.

On the west coast of North America, "*Saxicava*" *pholadis* Linnaeus was reported by B. L. Clark from the Poul Creek Formation in southern Alaska of late Oligocene or early Miocene age. In California, the genus has been reported from beds of middle and late Pliocene age as well as in beds of Pleistocene age, and Recent. In Japan species assigned to *Hiatella* have been reported from late Oligocene or early Miocene (1246) to Recent, and in Australia from Miocene to Recent.

Separation of the various species in some cases is difficult because of the variation in the shape of the shell which varies according to whether they burrow or they nestle in cavities. Another problem in connection with identification of these forms is whether some of them should be assigned to *Hiatella* or to juvenile *Panope*.

Dodge (1950) discussed the problem connected with the use of the names *Hiatella* and *Saxicava*. Dall (1247) recently discussed the Hiatellidae and listed the species referred to *Hiatella*.

Hiatella arctica Linnaeus
Plate 56, Figures 15, 17, 18

Mya arctica Linnaeus, Syst. Nat., ed. 12, p. 1113, 1767.

"Habitat in Oceano Norvegico." — Hanley, Ipsa Linn. Conch., pp. 28, 461, 1855. — Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 31, 1952. [Discussion of Linnaean species.]

Solen minutus Linnaeus, Syst. Nat., ed. 12, p. 1115, 1867. "Habitat in O. Norvegico. Martin." — Chemnitz, Neues Syst. Conchyl.-Cab., Bd. 6, p. 67, pl. 6, figs. 51, 52, 1782. Iceland; Greenland; Norway, Shallow and deep water. — Hanley, Ipsa Linn. Conch., pp. 32, 462, 1855.

Hiatella biaperta Bosc, Hist. Nat. Coq., Vol. 3, AN X [1801], p. 120, pl. 21, fig. 1. "Se trouve sur la côtes de Tranquebar." [India.]

Hiatella monoptera Bosc, Hist. Nat., Coq., Vol. 3, AN X [1801], p. 120, pl. 21, fig. 1. "Se Trouve sur les côtes de Tranquebar." [India.]

Didonta bicarinata Schumacher, Essai Nouv. Syst. Test., p. 125, pl. 6, figs. 2 (a, b), 1817.

Hiatella arctica Linnaeus, Lamarck, Hist. Nat. Anim. s. Vert., Vol. 6, p. 30, 1819. "Habite les mers du Nord, dans le sable, et se rencontre parmi les fucus." — Hertlein and Strong, Zoologica, Vol. 35, Pt. 4, p. 244, 1950. Port Guatulco, Mexico, to Piedra Blanca, Costa Rica. Also Arctic Ocean to Panama, and Atlantic. — Abbott, American Seashells (D. Van Nostrand Co., Inc., New York,), p. 452, fig. 92a, 1954. "Arctic Seas to deep water in the West Indies. Arctic Seas to deep

water off Panama." — Richards, Trans. Amer. Philos. Soc., New Ser., Vol. 52, Pt. 3, p. 71, pl. 12 figs. 17-20, 1962. Hudson Bay to North Carolina, Pleistocene. Recent: "Arctic to W. Indies in deep water. Arctic to off Panama in deep water."

Saxicava arctica Linnaeus, Sowerby, Reeve's Conch. Icon., Vol. 20, *Saxicava*, species 1, pl. 1, figs. 1a, 1b, 1c, 1d, 1875. "Arctic regions, British and North American coasts." — Sars, Bid. Kunds. Norges Arkt. Fauna. I. Moll. Reg. Arct. Norvegiae, p. 95, pl. 20, figs. 8a, 8b, 8c, 8d, 1878. Norway and Arctic regions. — Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 11 (Pelecypoda, Fasc. 24), p. 589, pl. 86, figs. 1-4 (typical); 5-11 (vars.), 1896. Various localities cited. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 208, pl. 9, fig. 6; pl. 51, fig. 4, 1924. Arctic Ocean to Panama. Also Atlantic. — Lamy, Jour. de Conchyl., Vol. 68, No. 3, p. 222, 1924. Numerous localities cited.

Type specimen. — "in the Linnaean cabinet" of the Linnean Society of London (Hanley, Ipsa Linn. Conchyl., p. 28, 1855).

Type locality. — "Habitat in Oceano Norvegico."

Range. — Oligocene to Recent. In western United States, Pliocene to Recent. Recent, Arctic Ocean to Panama (in deep water); to the West Indies (in deep water); northern Europe to the Mediterranean and west Africa. From the intertidal zone to at least 1829 meters (1000 fathoms) and perhaps deeper, usually burrowing or nestling in cavities.

Occurrence in San Diego Fm. — L.A.M. Loc. 107, 305, 305C.

Original description. — M. testa striata: valvulis carinis duabus spinulosis; cardiae edentulo. Habitat in Oceano Norvegico. *F. Zoega*. Testa magnitudine Fabae, rudis, facie Arcae noae, pallida. Antice retuso-planiuscula, parte anteriore obtusissima, posteriore brevior, acutiuscula; pars anterior a natus excurret angulis duobus remotis antrosum subaculeatis. Cavitas interna lactea est. Cardio vix ullus. (Linnaeus, 1767.)

Remarks. — The shell characters generally relied upon to identify *Hiatella arctica* and *H. pholadis* (1248) were summarized by Dodge (1952, pp. 32-33) as follows:

"*Saxicava arctica*: One tooth in the right valve and two in the left. Roughly quadrate in form and longer in proportion to width than *rugosa*. Spines on young or unworn specimens." [See illustrations by Sars, 1878, and Abbott, 1954.]

"*Saxicava pholadis*: A completely edentulous form. The concentric sculpture is weaker than in either of the others. Less quadrate than *arctica*. Spineless. More evenly rounded at the ends than the other two."

Hiatella arctica is here reported for the first time from the San Diego Formation. Two right valves about 6 mm long are present in the collection from Loc. 305 (LAM); two valves, the larger one about 5 mm long, from Loc. 305A (LAM); one small valve from Loc. 305C (LAM); and one very small left valve from Loc. 318 (LAM). All these are from localities near the Mexican boundary. A specimen with both valves from Loc. 107 (LAM) is 10 mm long.

The shell of this species is reported (Abbott, 1954) to attain a length of 76 mm (3 inches). We have seen a left valve 68.5 mm long and 35.3 mm high which was taken

by R. R. Talmadge from a cavity in a sponge dredged off Crescent City, Del Norte Co., California [Loc. 40733 (CAS)], in 750 meters (410 fathoms). Richards (1249) pointed out in a discussion of *Hiatella arctica* that "the heavy, coarse variety typical of the Pleistocene is limited to Arctic and sub-Arctic seas." Elton and Baden-Powell (1250) mentioned that there appears to be a tendency for the shell of *H. pholadis* to develop a thicker shell in the colder waters of its distribution also a tendency to be typically longer in warmer waters.

The species described as "*Saxicava*" *antarctica* Philippi (1251) is very similar to *H. arctica* and Dall (1252) expressed doubt that the South American species is distinct. We have noticed no difference, except in size, between specimens referred to *H. arctica* from off Costa Rica and those from boreal waters. Olsson (1253), however, believes it best to refer the Panamanian forms to *H. solida* Sowerby (1254).

The type locality originally cited for *H. solida* was Santa Elena, Ecuador. Dall (1255) stated that there is doubt concerning this locality and he mentioned that Sowerby in 1875 cited no locality for this species. He discussed (pp. 224-226) *H. arctica* and *H. solida* and considered the latter to be a species of southern South America but he mentioned that young shells of the two are indistinguishable. He observed that shells of *H. arctica* to a length of 15 mm have well developed hinge teeth but that these later become completely obliterated by an overgrowth of the nymph when 28 mm long whereas shells of *H. solida* 20 to 35 mm long still retain obvious hinge teeth. We have not had specimens from southern South America for comparison but most specimens of *H. arctica* 20 to 44 mm long which we have studied are virtually edentulous.

Hiatella arctica was reported from Germany by von Koenen (1256) from strata of middle Oligocene age and by Görges (1257) from beds of late Oligocene age. Cossman and Peyrot (1258) discussed its occurrence in beds of Miocene age in France. They mentioned that records of *H. rugosa* in beds of Miocene age are probably referable to *H. arctica* but pointed out that *H. vera* Deshayes from strata of Eocene age is a distinct species.

Many records of *Hiatella arctica*, subspecies such as *H. arctica bilineata* Conrad (1259), and others cited as *H. arctica* but later designated as distinct, such as *H. orientalis* Yokoyama (1260), have been reported from other parts of the world. The relationship of these various forms must await a careful study of the group.

The present record of the occurrence of *H. arctica* in the San Diego Formation is the earliest, geologically, reported from California. Soper and Grant (1261) reported this species from strata at Fifth and Hope streets in Los Angeles, considered to be of late Pliocene age.

Dall (1262) reported *H. arctica* from several localities in southwestern Alaska from beds assigned Miocene age. MacNeil (1263) later discussed these occurrences but did not find specimens to verify the age assignment. Dall (1264) also identified this species from beds probably of Pliocene age, in Lituya Bay, in southeastern Alaska. It also has been reported (1265) from the Daishaka Pliocene in Japan.

Hunter (1266) discussed the boring habits of *H. arctica* and more recently Ockelmann (1267) summarized much information concerning this and similar forms.

GENUS *PANOPE* MÉNARD

Glycimeris Lamarck, Mém. Soc. Hist. Nat. Paris, Vol. 1, p. 83, 1799. Sole species, "*Mya glycimeris*. Born. mus. t. 1, f. 8."

Not *Glycymeris* Da Costa, 1778.

Panope Ménard de la Groye, Mémoire sur un nouveau Genre de coquille bivalve-équivalve de la famille des solenoides, pp. 16, 31, January, 1807. Two species described, "*P. Aldrovandi*," p. 31 (synon. included *Mya glycimeris* Born), Recent, Europe, Mediterranean, Spain; and "*P. Faujas*," p. 33, pl. 12. "Se trouve fossile en Italie, à six milles au sud de Plaisance, dans le depot du Stramonte." Also reported Recent in Mediterranean; Spain.—Dall, Proc. Malacol. Soc. London, Vol. 10, Pt. 1, pp. 34-35, 1912.—Vokes, Jour. Paleo., Vol. 30, No. 3, pp. 766-777, 1956.

Panopaea Ménard, Lamarck, Extr. Cours. Zool., p. 108, 1912. Type designated by Children (Quart. Jour. Sci. Lit. and Arts., Vol. 14, p. 83, pl. 4, fig. 27, October, 1822): "*P. aldrovandi* (*Mya glycimeris* Linn.)."

Type species (designated by Schmidt, Versuch Conchyl.-Samml., p. 177, 1818). — "Type. *Mya glycimeris*" [Born, Index Mus. Caes. Vindobonensis, p. 10, 1778. No locality cited. (Ref. to Aldrovandi, Tes., l. 9, pp. 473, 474; Lister, Hist. Conch., l. 3, fig. 258; Gualtieri Test., t. 9 [90], fig. A.) — Born, Test. Mus. Caes. Vindobonensis, p. 20, pl. 1, fig. 8. 1780. For references to and a discussion of this species see Lamy, Jour. de Conchyl., Vol. 68, No. 4, pp. 267-269, 1925.]

Range. — Late Jurassic; Cretaceous to Recent. Recent from the littoral zone to 165 meters (90 fathoms).

Description. — Shell usually large, elongated, ventricose, anterior end rounded, posterior end truncated, gaping (more so posteriorly); beaks subcentrally placed; rather coarse concentric sculpture; hinge with one cardinal tooth in each valve; ligamental ridge large; pallial sinus well developed.

Remarks. — The earliest geologic occurrence of *Panope* is not known with certainty because of the lack of knowledge concerning the characters of the hinge and other features of ancient species which may or may not be referable to this genus. *Panope brockworthensis* from the inferior Oolite, late Jurassic of England, was described by Cox (1268) who discussed the difficulties of determining the genera of many Mesozoic fossils. He pointed out that some of those fossil forms might be referable to the genus *Myopsis* L. Agassiz for which genus he selected *Mya mandibula* Sowerby as type. *Pleuromya* L. Agassiz, confined to the Mesozoic, has a smaller posterior gape and a depression which extends from the umbos to the anterior end and the shell is nacreous rather than porcelaneous.

Five species of *Panope* have been recorded occurring in Tertiary strata of California. One Recent subspecies of the California form has been described from Scammon's Lagoon, Lower California, and one species from the Gulf of California. Others have been described from the Cenozoic of South America.

Lamy (1269) published a useful summary of the Recent species of *Panope*.

About a dozen Recent species of this genus occur in the present seas mostly in cool and temperate water

but a few occur in subtropical waters. These mollusks usually burrow in sandy mud which is exposed at low tide.

Vokes (1270) discussed the name *Glycimeris* Lamarck (not Da Costa), an earlier name for *Panope*.

Deschaseaux (1271) placed *Panope* in the family "Panopaeidae Zittel".

Panope generosa Gould
Plate 56, Figures 19, 20

Panopaea generosa Gould, Proc. Boston Soc. Nat. Hist., Vol. 3, p. 215, May, 1850. — Gould, U.S. Explor. Exped (Wilkes), Vol. 12, Mollusca, p. 385, 1852, Atlas, p. 13, pl. 34, figs. 507, 507a, 507b, 1856. — J.P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, pp. 173, 182, 1912. "San Diego-Purisima. Pliocene." — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 205, pl. 2, figs. 1, 2, 1924 (reproduction of Gould's original figures 507a, 507b). "Puget Sound to San Diego, California." Also Pleistocene and Pliocene.

Panopea generosa Gould, Arnold, U.S.G.S., Bull. 396, p. 31, pl. 18, fig. 4, 1909. "Upper Etchegoin formation." also Upper Miocene to Recent. Also Bull. 398, pl. 40, fig. 4, 1910. (Same figure). — Reagan, Trans. Kansas Acad. Sci., Vol. 22, p. 204, 1909. "Purisima-San Diego" formation of California.

Panopea genrosa Weymouth, Calif. State Fish Game Comm., Fish Bull. No. 4, p. 63, pl. 18, fig. 2, 1920. California coast.—I.S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 63, pl. 16, figs. 1, 2, 1924. [Reproduction of Gould, 1856, pl. 34, figs. 507a, 507b.] Vancouver Island to San Diego, California.—Hertlein, Stanford Univ. Bull., Ser. 5, No. 78, p. 82, 1929. "San Diego Pliocene."—Fitch, Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 92, fig. 58, 1953. "Range: Forrester Island, Alaska, to Scammons Lagoon, Baja, California."

Panope (Panope) generosa Gould, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 424, pl. 21, figs. 12a, 12b, 1931. Miocene to Recent. [Not all the synonymy.]

Panope (Panope) abrupta Conrad, Moore, San Diego Soc. Nat. Hist., Occas. Paper 15, p. 42, pl. 19, 1968. Balboa Park, San Diego, Pliocene.

Type specimen.—Holotype No. 5894, United States National Museum.

Type locality. — "Hab. Puget Sound, Oregon." [Washington.]

Range. — "cf." Early Miocene (Vaqueros). Middle Miocene (Tembler) to Recent. Recent from Forrester Island, Alaska, to Scammon's Lagoon, Lower California, Mexico, between tides, burrowing to a depth of four feet or more in unshifting sandy mud beaches in bays, estuaries and sheltered areas. Burch reported dredging empty shells at a depth of 46 meters (25 fathoms) off Redondo Beach, California (Min. Conch. Club South. Calif., No. 44, p. 30, February, 1945.)

Occurrence in San Diego Fm. — C.A.S. Loc. 1400, 1402, 1418, 28885, 28889. L.A.M. Loc. 107, 305, 305A, 319. S.D. Loc. 4, 27, 29 [=Loc. 1402 (CAS)]; Loc. 34, Cat. nos. 6386, 6387, 6389, Pacific Beach (casts).

U.C.L.A. Loc. 2359.

Original description: Test magna, ponderosa, calcarata, sub-quadrilateralis, concentricè unduloso-plicosa, epidermide flavido, rugoso induta, anticè rotundata, posticè truncata et valdè hians; umbonibus submedianis, acutis, elevatis, undulatis: cardo gracilis, dente elevato oblique triangulari instructus: cavitas ad apicem profunda; cicatrice musculari lato, benè impresso; sinu siphonali minimè profundo. Long. 6; alt. 4; lat 3 poll. (Gould.)

Remarks: A number of specimens from the San Diego Formation, in various states of preservation, agree in all observable characters with Recent *Panope generosa*. The largest specimen (incomplete), from Loc. 305 (LAM) is 135 mm long. Another from the same locality is 98 mm long, 63 mm high, convexity (both valves together) 41.6 mm. A specimen from Loc. 305A (LAM) is 114 mm long and 75 mm high. Many fragments from these two localities are present in the collections of the Los Angeles County Museum. The largest specimen from the San Diego Formation in the collections of the California Academy of Sciences is 102 mm long (incomplete). The largest Recent specimen in the Academy's collection is one collected in Puget Sound by Henry Hemphill, which is 186.9 mm long, 101.5 mm high, convexity (both valves together) 73.2 mm. Fitch (1953) mentioned that huge Recent specimens of this mollusk (including the animal) may weigh eight pounds.

There is variation in the shape of the fossils in the present collections. The valves of some specimens are more convex than others and on some the posterior dorsal margin is nearly straight, on others concave. Similar variations can be observed in a series of Recent specimens and are no doubt the result of the burrowing habit of this mollusk.

Panope generosa solida Dall (1272) was described with the locality cited as San Francisco, California. According to Dall, this differs from the typical form in that the ligamentary attachment is twice as long and the pallial sinus is deeper. Experienced collectors have not since found *P. generosa* nor any variety of it in that area and according to Packard (1273) no specimens were taken by the *Albatross* in their dredgings in and near San Francisco Bay. The illustration of this form given by Oldroyd (1274) is that of a broad, subquadrate shell and it was said to occur with the typical form throughout most of its range but Keen (1275) pointed out that there are questions concerning the specimen illustrated as type by Oldroyd.

Panope globosa Dall (1276) described from the north end of the Gulf of California was said to be characterized by the shell "of a yellowish white color, shorter, thinner, and more globose than *P. generosa* and probably distinct."

We have examined two valves of this form collected by E.P. Chace on the beach about 20-25 miles south of San Felipe, Lower California. These are more globose and the posterior end is narrower than comparable specimens of *P. generosa*, and apparently represent a distinct species. The right valve is 151 mm long, 106 mm high, the convexity (one valve) 38 mm.

Records of *P. generosa* from beds of Pliocene age in the Gulf of California region are probably referable to *P. globosa*.

Several named forms from the Cenozoic of western

North America are either identical with or very closely allied to the Recent species. The form from the middle Miocene at Astoria, Oregon, named *Mya abrupta* (1277) by Conrad may be identical with *Panope generosa*. Moore (1278) examined the type specimen of Conrad's species and considered *Panope generosa* to be identical and placed the latter in the synonymy of *P. abrupta*. She described the type specimen of *P. abrupta* as a thin-shelled form 65.8 mm long and 39.2 mm high. This is smaller than most adult shells of *P. generosa*. The west American species of *Panope* are in need of monographic study. For the present we use the name *Panope generosa* for Recent and for the Pliocene specimens mentioned in the present report.

There have been differences of opinion by authors concerning the Miocene species named *Glycimeris estrellanus* (1279) by Conrad. The original figure is that of an imperfectly preserved specimen, and there is doubt concerning its specific characters. Moore (1963, p. 83-84) placed it in the synonymy of *P. abrupta*. Clark (1280) discussed what he considered to be the differences between this fossil and the Recent *Panope generosa*. Later the same author proposed the name *Panope ramonensis* (1281) for a fossil from near Walnut Creek, California, in beds which he referred to late Oligocene age. In the synonymy of this species he cited the "*Panope cf. estrellana* Conrad" of his earlier work.

Panope tenuis Wiedey from Temblor strata of middle Miocene age and *P. taeniata* Dall described from beds of Pleistocene age at Magdalena Bay, Lower California, are both much narrower posteriorly than the Recent species described by Gould. The type specimen of *Panope similis* Dall and Ochsner from Pliocene strata in the Galapagos Islands also is more attenuated than typical *P. generosa*.

The species occurring in Japan from Miocene to Recent, cited by some authors under the name of *Panope generosa*, is now referred to *Panope japonica* A. Adams (1282)

GENUS PANOMYA GRAY

Panomya M. E. Gray, *Fog. Moll. Anim.*, Vol. 5, p. 29, pl. 346, fig. 1, 1857. Sole species, "*P. norvegica*, t. 346, f. 1." — Dall, *Trans. Wagner Free Inst. Sci.*, Vol. 3, Pt. 4, p. 832. 1898. "Type *Panopea* (*Mya*) *norvegica* Spengler." — Lamy, *Jour. de Conchyl.*, Vol. 68, No. 4, p. 261, 1925. Type, *Mya norvegica* Spengler. = *Panopaea spengleri* Valenciennes. — Grant and Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, p. 425, 1931. Type (by monotypy), *Mya norvegica* Spengler.

Type species (by monotypy). — *Panomya norvegica* Spengler | = *Mya norvegica* Spengler, *Acta Soc. Hist. Nat. Hafn.*, Vol. 3, p. 46, pl. 2, fig. 18, 1793. (Not *Mya norvegica* Gmelin, 1790, which is a *Lyonsia*.) Illustrated by M. E. Gray, 1857, pl. 346, fig. 1. — Gould, *Rept. Invert. Massachusetts* (Boston), (edited by W. G. Binney), p. 52, fig. 373, 1870 (as *Panopaea arctica* Lamarck). — Sowerby, *Reeve's Conch. Icon.*, Vol. 19, *Panopaea*, sp. 7, pl. 5, fig. 7, 1873 (as *Panopaea spengleri* Valenciennes.) — Davies, *Tertiary Faunas* (T. Murby & Co.: London), p. 201, fig. 269 (p. 196), 1935. — N. Macginitie, *Proc. U. S.*

Nat. Mus., Vol. 109, No. 3412, p. 189, pl. 19, fig. 1; pl. 25, figs. 6, 8, 1959 (as *Panomya arctica*).

Range.—Late Oligocene or early Miocene to Recent. Recent, from the intertidal zone, occasionally 46 to 600 meters (25 to 328 fathoms).

Description. — Shell differs from *Panope* in that it is shorter in proportion to the height, in the presence of a pronounced medial radial depression and in that the pallial line is broken into an irregular series of rounded impressions.

Remarks.—This genus has been reported from Japan from late Oligocene or early Miocene to Recent: from the northeastern Pacific from late Miocene or Pliocene to Recent and in the Arctic region and in northern Europe from Pliocene to Recent. It is essentially an inhabitant of intertidal or shallow boreal and Arctic waters. However, the type species, *Panomya arctica* in the Atlantic, has been reported (1283) from depths of 530-600 meters (290-328 fathoms).

At the present time *Panomya* has not been reported living south of Puget Sound along western north America, but during Pliocene time it occurred as far south as San Diego, California. The fossil and Recent species of *Panomya* from Japan have been discussed by Kanno (1284).

A large specimen of *Panomya gigantea* Kanno from strata of Pliocene age in Japan, is 137 mm long and 98 mm high.

Panomya cf. P. beringiana Dall
Plate 56, Figures 12

The following references, type locality and range refer to typical *P. beringiana*.

Panomya beringiana Dall, *Proc. U. S. Nat. Mus.*, Vol. 52, No. 2183, p. 416, December 27, 1916. — I. S. Oldroyd, *Stanford Univ. Publ. Univ. Ser. Geol. Sci.*, Vol. 1, p. 207, 1924. Type locality cited. Range: eastern Bering Sea. — Woodring, Bramlette, and Kew, *U. S. G. S., Prof. Paper 207*, p. 85, pl. 33, figs. 13, 14, 1946. Timms Point Silt, San Pedro, Pleistocene.

Type specimen. — No. 212875, United States National Museum.

Type locality. — "Station 3529, near the Pribiloff Islands, in 56 fathoms."

Range. — Late Pliocene to Recent. Recent from the Aleutian Islands to Puget Sound in 102 to 146 meters (56 to 80 fathoms). Probably also in Japan.

Occurrence in San Diego Fm. — C.A.S. Loc. 1418. L.A.M. Loc. 305.

Original description. — Shell resembling *P. arctica* Lamarck, in a general way, but thinner, less cylindrical, much larger, and proportionately shorter. Length, 130; height, 80; diameter, 50 mm. (Dall, 1916.)

Remarks.—Two specimens from the San Diego Formation in the collections of the California Academy of Sciences are referable to the genus *Panomya*. The specimens are incomplete casts which retain only portions of the shell. The larger of these is 52.5 mm long and 46 mm high. A very well developed radial median depression is present on these fossils. A fragment of a thin shell 30 mm long, from Loc. 305 (LAM), appears to be referable to the

same species.

Several species of *Panomya* have been recorded from boreal west American waters. The earliest valid name appears to be *Glycimeris arctica* Lamarck (1285). *Mya norvegica* Spengler, 1793, is a synonym of Lamarck's species because of an earlier *Mya norvegica* Gmelin, 1790, which is referable to the genus *Lyonsia*.

Dall in 1898 described *Panomya ampla* (1286) in the synonymy of which he placed "*Panopaea norvegica* Spengler" illustrated by Middendorff (1287). Dall characterized this species as follows: "This differs from *P. norvegica* by its much more heavy and rude shell, with a more expanded posterior region, and flatter, more irregular valves." His illustration is that of a decidedly trigonal valve, the dorsal margin nearly straight and the anterior end very narrow in comparison to the broad posterior end. MacNeil (1288) in 1943 cited *P. ampla* from beds of Pliocene and perhaps Pleistocene age from near Nome, Alaska. His illustration shows a right valve which anteriorly tapers to a blunt point. Oldroyd (1289) illustrated a shell under the name of *Panomya ampla* from Puget Sound the shape of which is more that of *P. beringiana* but according to MacGinitie (1959, p. 189) this illustration represents "*P. turgida* (= *P. arctica*)." Grant and Gale (1290) also illustrated a shell from the same region which, according to Woodring (1946, p. 85) resembles *P. beringiana*. The illustration by Kira (1291) of a species from Japan under the name of *P. ampla* likewise appears to be referable to *P. beringiana*. The illustrations of Grant and Gale and that of Kira were all referred to *P. arctica* by MacGinitie, who, however, did not refer to *P. beringiana*.

The next species in chronological order of date of description is *Panomya (ampla var.?) chrysis* Dall (1292), a fossil from the Empire beds of Pliocene age at Coos Bay, Oregon. Dall considered this to differ from *P. ampla* "from which the valves differ in being thin, instead of enormously thickened, and in wanting the conspicuous anterior oblique truncation of the living species." Howe (1294) placed this in the synonymy of *P. ampla* and this arrangement was followed by Grant and Gale. We have examined a cast of the type specimen of the fossil from Coos Bay, Oregon, and can add nothing to Dall's observations on that form.

In 1916 Dall described two forms from Alaska, *Panomya beringiana* and *Panomya arctica* var. *turgida*. *Panomya beringiana* was described as differing from *P. arctica* in the thinner shell, less cylindrical form, and in the larger size and proportionally shorter shell. The illustration of species by Woodring, Bramlette, and Kew, shows a shell which is anteriorly attenuated and rounded at the end and the anterior dorsal margin slopes downward and does not form an almost straight line with the posterior dorsal margin as does that of *P. ampla*.

Panomya arctica turgida Dall (1294) was described as "shell very similar to the North Atlantic form but very much more capacious and larger. Length, 90; height, 60; diameter, 48 mm. Cat. No. 151334, U. S. N. M." Clark (1294) illustrated a fossil from the Yakataga Formation in southeast Alaska of late Miocene or early Pliocene age. This form appears to be much more elongate, more cylindrical, and to have a thicker shell than do the fossils from the San Diego Formation. According to Woodring, *P. turgida* is more inflated and has a less conspicuous median groove than the late Pliocene or Pleistocene fossils

from the Los Angeles district which he referred to *P. beringiana*.

There has been confusion in the literature concerning the three forms described by Dall. Woodring (1946, p. 85) stated that records of *P. ampla* and *P. turgida* from beds of Pliocene and Pleistocene age in southern California are referable to *P. beringiana*. Eyerdam (1296) pointed out that a species in his collection from Victoria, British Columbia, formerly believed to be *P. ampla*, was later identified by A. M. Keen as *Panomya turgida*. Schlesch (1297) considered *P. turgida* to be a virtual synonym of *P. norvegica*.

From the foregoing it appears that the several named forms of *Panomya* in the northeastern Pacific are quite similar and that too many names have been proposed for them. A species from Japan compared with *P. ampla* was described as *Panomya nipponica* by Nomura and Hatai (1298). Habe (1299) recorded *P. ampla* from Japan and stated "as the writer observed all kinds of transitional forms among *P. ampla*, *P. turgida* and *P. nipponica* in many species from Nemoro and Akkeshi, those three species seem to be merely the local or individual forms of one species." Kanno (1957, p. 13) concurred in this opinion.

The imperfect preservation of the fossils from San Diego makes identification of the species doubtful. The median depression on these fossils is more pronounced than it is on Dall's type specimen of *P. ampla chrysis* Dall from the Empire beds at Coos Bay, Oregon.

We compare the present fossils to *P. beringiana*, whose shell characters are well known, because of the general similarity, the pronounced median groove and thin shell. Furthermore, what is probably this species has been recorded occurring in the Careaga Sandstone of Pliocene age in the Santa Maria district (1300) and Faustman (1301) has recorded it from strata of middle Pliocene age in Humboldt Co., California. We have observed a lot of 16 specimens of *P. beringiana* from near the latter locality which were collected by Bruce Martin at Loc. 119 (CAS).

SUPERFAMILY PHOLADACEA

RAFINESQUE (1302)

FAMILY PHOLADIDAE RAFINESQUE (1303)

Shells with a narrow, slit-like to nearly circular pedal gape, which may or may not be closed by a callum in the adult stage. Anterior portion of the valves imbricate and often ribbed. This portion is often separated from the posterior portion by an umbonal-ventral sulcus. Hinge teeth usually lacking, a small chondrophore present in some forms, ligament if present, internal. Anterior dorsal margin of the valves reflected, forming the attachment area for the externally placed anterior adductor muscle. In the adult stage of most forms the chitinous cover (cephalic hood) of the anterior adductor muscle is covered by accessory plates or by a dorsal extension of the callum. The total number of accessory plates in any one species may vary from one in *Barnea* and *Zirfaea* to four in *Martesia* and *Parapholas*. Apophyses are present in the Pholadinae and Martesiinae, but absent in the Jouanneitiinae and Xylophaginae. Pallial sinus usually deeply in-

set. (Adapted from Turner.) Jurassic to Recent.

Remarks. — The members of this group of mollusks occur world wide and live from the intertidal zone to a depth of 457 meters (250 fathoms). They burrow into rock, wood, or other shells. The greatest number of genera occur in warm temperate, subtropical and tropical waters. Turner pointed out that the greatest development of this group is in the eastern Pacific where there are 13 genera and 23 species in comparison to 8 genera and 13 species in the western Atlantic.

An excellent work by Turner (1304) deals with the Pholadidae of the western Atlantic and of the eastern Pacific. Lamy (1305) discussed the species in the collections of the Natural History Museum in Paris.

Key to Genera of Pholadidae

- A. Callum present; shell gaping
along posterior half of dorsal
and ventral margins *Penitella*
- B. Callum lacking; shell gaping
only at both ends *Zirfaea*

GENUS ZIRFAEA GRAY

Zirfaea Gray, Synop. Brit. Mus., ed. 42, p. 150, 1840. [No description nor species.] — Gray, Synop. Contents Brit. Mus., ed. 44, p. 76, 1842. [Brief description, no species cited.] [Concerning the preceding references, see Iredale, Proc. Malacol. Soc. London, Vol. 10, Pt. IV, pp. 298, 303, 309, March, 1913.] — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 432, 1931. "Type (by subsequent designation, Gray, 1847), *Pholas crispatus* Linnaeus." — Turner, Johnsonia, Vol. 3, No. 33, p. 54, 1954. "Genotype, *Pholas crispata* Linné, subsequent designation, Gray, 1847."

Thurlosia Catlow and Reeve, The Conchologist's Nomenclator, p. 3, 1845. "*Thurlosia crispata*, Leach" cited in synonymy of "*P. crispata*, Linn., Syst. Nat. p. 111; Enc. méth. pl. 169, f. 5-7."

Zirphaea Leach, Synop. Moll. Great Britain, pp. 250, 252, 1852. *Zirphaea crispata* Linnaeus and synonymy cited.

Type species (by subsequent designation, Gray, Proc. Zool. Soc. London for 1847, p. 188, 1847).—"*Ph. crispata*" [= *Mya crispata* Linnaeus, Syst. Nat., ed. 10, p. 670, 1758. Ref. to "List. angl. t. 5. f. 38" and "app. t. 2. f. 7." "Habitat in O. septentrionali." Also illustrated by Sowerby in Reeve's Conch. Icon., Vol. 18, *Pholas*, pl. 3, fig. 9, 1872. "Hab. Great Britain." — Turner, 1954, p. 55, pls. 1, 3, 28, 29, and pl. 30, figs. 1-3].

Range. — Middle Miocene (Temblor) to Recent. Recent in boreal and warm temperate waters of the Atlantic and Pacific oceans of the northern hemisphere; boring in consolidated mud or clay, rock, occasionally wood, from the intertidal zone to 128 meters (70 fathoms).

Description. — Shell oval in outline, beaked anteriorly, rounded to truncate posteriorly, widely gaping at both ends and having a sulcus extending from the umbo to the ventral margin. There is a single dorsal accessory

plate, the mesoplax, which is small and more or less triangular in outline. Apophyses solid, strongly curved, broadened and often spoon-shaped at the free end. (Turner, 1954.)

Remarks. — Two species of *Zirfaea* have been reported from beds of late Tertiary age in California, one of which now lives in west American waters. *Zirfaea* is here reported from the San Diego Formation for the first time.

Zirfaea cf. *Z. pilsbryi* Lowe

The following references, type locality, range and description refer to typical *Z. pilsbryi*.

Zirfaea gabbi Tryon, I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 210, pl. 36, fig. 1, 1924. "Bering Sea and islands south to San Diego." [Not the locality "Japan."] Also Pleistocene.

Not *Zirphaea gabbii* Tryon, Proc. Acad. Nat. Sci. Philadelphia, Vol. 15, p. 144, pl. 1, fig. 1, 1863. "Hab. Coast of Japan?"

Zirfaea pilsbryi Lowe, Nautilus, Vol. 45, No. 2, p. 53, pl. 3, figs. 1, 2, October, 1931. "Bollinas, California." — Morris, Field Guide to Shells of the Pacific Coast and Hawaii (Houghton Mifflin Co.: Boston, Massachusetts), p. 63, pl. 18, fig. 7, 1952. "Bering Sea to Lower California." — Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 95 fig. 61, 1953. "Nunivak Island, Alaska, to San Juanico Bay, Baja California." — Turner, Johnsonia, Vol. 3, No. 33, p. 58, pl. 30, figs. 4-9; pls. 31-34, 1954. Various localities cited. Range same as cited by Fitch.

Type specimen. — No. 50809, Academy of Natural Sciences of Philadelphia.

Type locality. — "from Bollinas, California."

Range. — ? Late Miocene; Pliocene to Recent. Recent from Nunivak Island, Alaska, to San Juanico Bay, Lower California, Mexico, from the intertidal zone to 24 meters (13 fathoms); boring in mud and in clay banks to a depth of 25 to 30 cm., occasionally in water-logged wood.

Occurrence in San Diego Fm. — L.A.M. Loc. 305.

Original description of *Z. pilsbryi*. — Shell large, transverse, obliquely divided by a shallow furrow proceeding from the umbonal apex to the basal margin and forming a corresponding rib on the internal surface of valve. Posterior to the furrow the shell is marked only by growth wrinkles; on the anterior half they appear as sharp ribs which are produced into sharp spines in unevenly spaced radiating lines continuing to the sharply crenulated margin. Diameter of type, 36 mm.; alt., 37 mm.; length 75.5 mm. (Lowe.)

Remarks. — The present record of *Zirfaea* cf. *Z. pilsbryi* from the San Diego Formation is based upon fragments, the largest about 15 mm long. These retain the widely spaced concentric sculpture surmounted by fine spines such as occur on the anterior dorsal portion of valves of Recent *Z. pilsbryi*.

The shell of Recent *Z. pilsbryi* is longer and narrower and the internal apophyses broader and more concave than those of the shell of *Z. crispata* Linnaeus, a European species.

Turner (1954) gave a thorough description of *Z. pilsbryi* and MacGinitie (1306) discussed its ecology and

boring habits. More recently Yonge (1307) also remarked on the boring habits of this species.

A subspecies, "*Zirfaea gabbi Tryon femii*" Adegoke (1308), was described from the San Joaquin Formation of late Pliocene age in the Coalinga district. It is said to differ from the typical subspecies in the more elongated outline, more widely spaced concentric lamellae on the anterior end and in other features.

GENUS *PENITELLA* VALENCIENNES

Penitella Valenciennes, in Abel du Petit-Thouars, Voyage autour du monde sur la Frégate La Vénus, Atlas de Zoologie, Mollusques, pl. 24, 1846. [No text.] Species cited: "*Penitella conradi*. (Nob.)," "*Penitella xilophaga*. (Nob.)," "*Penitella tubigera*. (Nob.)," — Turner, Johnsonia, Vol. 3, No. 34, p. 70, March 29, 1955. "Genotype, *Penitella conradi* Valenciennes, subsequent designation Habe 1952."

Type species (subsequent designation by Habe, Gen. Jap. Shells, Pelecypoda, No. 3, p. 243, May, 1952). — "Type species: *Penitella conradi* Valenciennes."

Range. — Late Oligocene (San Ramon) to Recent in the north and northeast Pacific. Recent from intertidal zone to a depth of 79 meters (43 fathoms).

Description. — Shells small to moderate in size, the larger species reaching about 95 mm (about 3 3/4 inches) in length, oval in outline, divided into two distinct regions by an umbonal-ventral sulcus and producing a callum in the adult stage. Shell beaked and widely gaping anteriorly in the young stage, with a nearly circular pedal gape. Valves rounded to truncate and closed posteriorly, the siphon being capable of complete retraction within the shell. Umbonal reflections variable, ranging from those which are thin and very closely appressed so that the sculpture of the shell shows through, to those which are heavy and free anterior to the umbos. Protoxap lacking, being replaced by the dorsal extension of the callum. Mesoplax transverse, in one piece and, in young specimens, very similar to that found in *Zirfaea*. In the adult, a dorsal portion is added to the mesoplax which grows forward and encloses the posterior portion of the anterior adductor muscle. Metapax and hypoplax lacking, siphonoplax variable, present or absent. Siphonal tube lacking. (Turner.)

Remarks.—The shell of *Penitella* differs from that of *Pholadidea* Turton (1309) in that the mesoplax is in one piece rather than divided longitudinally into two more or less triangular pieces, the two portions of the siphonoplax are not fused and are often diverging, the apophyses are thick, expanded and often blade-like at the free end, whereas those of *Pholadidea* are small, narrow and fragile.

Five species of *Penitella* live in the eastern Pacific in the region between Bering Island, Siberia, and Bahía Tortola (Turtle Bay), Lower California, and an equal number of species has been reported from the late Tertiary in the same region. Two of these are present in the collections from the San Diego Formation. Two Recent species and one fossil form have been reported recently from Japan (see Adegoke, Proc. Calif. Acad. Sci., Ser. 4, Vol. 35, No. 1, p. 18, 1967.)

Key to Species of *Penitella*

- A. Shell short and globose; mesoplax pointed anteriorly, truncated posteriorly; maximum length about 33 mm *conradi*
- B. Shell elongately ovate; mesoplax pointed posteriorly, truncated anteriorly; maximum length about 93 mm *penita*

Penitella conradi Valenciennes Plate 57, Figures 5, 13

Penitella conradi Valenciennes, in Abel du Petit-Thouars, Voy. autour du monde sur la Frégate La Vénus, Atlas de Zool. Moll., pl. 24, fig. 1, 1846. [No description nor locality.]—Lamy, Bull. Mus. Nat. Hist. Nat., Paris, Vol. 27, No. 2, p. 179, 1921. Monterey, California. — Lamy, Jour. de Conchyl., Vol. 69, No. 3, p. 152, 1926. Earlier records cited. — Turner, Johnsonia, Vol. 3, No. 34, p. 75, pls. 43-46, 72, figs. 1, 2, March 29, 1955. Range, "From Gualala, Mendocino County, California south at least as far as Bahía San Bartolomé, Baja California."

N[avea]. subglobosa Gray, Ann. Mag. Nat. Hist., Ser. 2, Vol. 8, No. 47, p. 385, November, 1851. "Hab. California, in a hole in a shell."

N[avea]. Newcombii Tryon, Amer. Jour. Conch., Vol. 1, Pt. 1, p. 39, pl. 2, figs. 1-3, February 25, 1865. "Habitat Australia." In Vol. 1, Pt. 3, p. 285, July 1, 1865, it is stated "Dr. Newcomb informs us that the locality of *Navea Newcombii*, stated in our description of that species, (p. 39) is erroneous. The specimens were extracted from a *Haliotis* from Lower California."

Penitella parva Tryon, Amer. Jour. Conch., Vol. 1, Pt. 1, p. 39, pl. 2, figs. 4, 5, February 25, 1865. "Habitat, Lower California, in *Haliotis*."

Type specimen. — Muséum Nationale d'Histoire Naturelle de Paris.

Type locality. — Monterey, California (from label with type specimen) (Lamy).

Range. — Middle Pliocene to Recent. Recent from Vancouver Island, British Columbia, to Bahía Tortola (Turtle Bay), Lower California, and possibly further, often boring in shell of *Haliotis*, or in clay or soft rock, from intertidal zone to 18 meters (10 fathoms).

Occurrence in San Diego Fm. — L.A.M. Loc. 305.

Description. — No original description. Diagnostic characters given by Turner, 1954, are: Shell usually found boring into *Haliotis* or other shells; occasional specimens are found in clay and soft stone. Umbonal reflections broad and closely appressed for their entire length. Mesoplax truncate posteriorly, pointed anteriorly and lacking lateral wings. Siphonoplax heavy, not diverging and composed of a chitinous outer layer which is lined with a white, granular, calcareous deposit.

Remarks. — Two small, oval, nearly smooth valves of *Penitella conradi* in the present collections were in a hole bored in a fragment of a shell (possibly a pectenoid). Dr. Ruth Turner kindly verified the identification of the species. A large specimen from Loc. 305C, the mesoplax

lacking, the interior filled with soft sandy silt, is 25 mm long, 20.3 mm high, convexity (both valves together), 19.2 mm. The shell characters of this specimen agree well with those shown in Turner's illustrations of *P. conradi* as well as with those of Recent specimens identified as that species in the collections of the California Academy of Sciences.

Specimens of *Penitella conradi* are similar to those of juvenile *P. penita* but can be separated from the latter by the shorter, more rounded posterior slope and by the shorter, more sharply upturned concentric ridges on the anterior portion of the shell.

Turner (1955) gave a thorough discussion and good illustrations of *P. conradi*. Large Recent specimens were reported by her to be 33 mm long and 16.5 mm high. She included *Martesia intercalata* Carpenter (1310) from Mazatlan, Mexico, in the synonymy but that locality was not included in the range given for *P. conradi*.

Smith (1311) recently discussed the morphology of *P. conradi* relative to its ability to penetrate shell material.

Penitella penita Conrad

Plate 56, Figures 8, 9, 16; Plate 57, Figures 1, 2

P[holas]. penita Conrad, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 237, pl. 18, fig. 7, 1837.

Pholas concamerata Deshayes, Rev. Zool., Soc. Cuvierienne, [Vol. 2] p. 357, Ann. 1839. "Californie, dans les marnes calcaires des rivages." — Deshayes, Mag. de Zool., Guérin-Méneville, Ser. 2, Vol. 2, pl. 17, 1840.

Penitella spclaeum Conrad, House Doc. 129, Projected Vol. 3, 33rd Congress, 1st Session, 1855. App. to Prelim. Geol. Rept. of W. P. Blake, p. 16. "Locality.—San Pedro. Recent formation." — Conrad, U. S. Pacific Railroad Expl., Vol. 5, Pt. 2, Art. 2, pp. 319, 326, pl. 5, figs. 43, 43a, 43b, 1857 (as *P. spclaca*). Locality same as in preceding reference.

Penitella curvata Tryon, Amer. Jour. Conch., Vol. 1, Pt. 1, p. 40, pl. 2, figs. 6, 7, 8, February 25, 1865. "Habitat, Straits of Fuca."

Pholadidea sagitta (Stearns MS.), Dall, Proc. U. S. Nat. Mus., Vol. 52, No. 2183, p. 417, December 27, 1916. "The type-specimen comes from Monterey, California." [A young specimen according to Turner, 1954.]

Pholadidea penita Conrad, I. S. Oldroyd, Stanford Univ. Publ. Ser. Geol. Sci., Vol. 1, p. 211, pl. 21, fig. 10 (copy of Conrad's original figure); pl. 51, figs. 3a, 3b, 1924. "Range. Chirikoff Islands, Alaska, to San Pedro, California."

Penitella penita Conrad, Fitch, State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 97, fig. 63, 1953. "Range: Chirikoff Island, Alaska, to Turtle Bay, Baja California." — Turner, Johnsonia, Vol. 3, No. 34, p. 80, pls. 5 (fig. No. 33), 47-51, 1955. Bering Island, Siberia, to Bahía Bartolomé (Turtle Bay), Lower California. — Evans, Proc. Malacol. Soc. London, Vol. 38, Pt. 2, pp. 111-119, pls. 1-4, figs. 1-6 in text, August, 1968. Oregon, Recent.

Type specimen. — Location unknown to the present authors.

Type locality. — "Inhabits with the preceding". [That is, *P. californica* and *Cypricardia californica* which

"Inhabits soft argillaceous rocks, which are bare at low water, with the Pholades, in the vicinity of Sta. Diego and Sta. Barbara."]

Range. — Middle Miocene (Topanga Formation) to Recent. Recent from Bering Island, Siberia, to Point Abrejos (1312), Lower California, Mexico, in intertidal zone, in cavities excavated in clay, hard rock, or cement. Dredged at the depth of 79 meters (43 fathoms).

Occurrence in San Diego Fm. — S.D. Loc. 417. Loc. 312 [= 417 (SD)].

Original description. — Shell ovate, elongated, contacted submedially and grooved; anterior side inflated, with decussating lines, the radiating striae having a granulated appearance, posterior side subcuneiform, extremity truncated, with a membranous expansion or appendage; apophysis oblique, slender, spoon shaped at the extremity. (Conrad.)

Remarks. — One right and three left valves are present in the collections from San Diego studied by us. These are single valves, imperfectly preserved, the largest is 52 mm long, 28.6 mm high, convexity, 14 mm. Large Recent specimens attain a length of 92 mm.

The accessory plates are lacking on the fossils in the present collections and identification of the species is based upon other shell characters. The shape of the mesoplax, when present, pointed posteriorly, easily serves to separate this species from similar ones. The broad, closely appressed umbonal reflection on the present specimens is characteristic of *Penitella penita* in comparison to the narrower, higher reflection present on *P. gabbi* Tryon and *Chaceia ovoidea* Gould. The shell of *P. penita* attains a much greater size than that of *P. conradi* Valenciennes which rarely exceeds 33 mm in length. The mesoplax of *P. conradi* is truncated posteriorly rather than pointed. The callum of adult specimens of *P. penita* is complete, that of *P. fitchi* is not complete but has a pedal gape, that of *P. gabbi* does not cover the extreme anterior end of the valves. All these west American species have been discussed and illustrated by Turner. The shape of the shell of *P. penita* is variable and may be a result of crowding or to the hardness of the substrate (Evans, 1968).

Penitella penita has not been recorded with certainty as occurring earlier than in beds of middle Miocene (1313) age. A fossil was cited as "*Pholadidea* aff. *penita* Conrad" by Clark (1314) from beds of Oligocene age southwest of Walnut Creek, California, but the state of preservation precluded positive identification. The same author later described a species from the same area under the name of *Pholadidea (Penitella) lorenzana* (1315). This fossil form was described as differing from *P. penita* in the much greater size, wider mesoplax which is pointed at the anterior end and the upper surface flat rather than concave.

Penitella turnerae Evans and Fisher (1316) described from Coos Bay, Oregon, differs from *P. penita* by its lack of a siphonoplax and by its larger size. Furthermore, the mesoplax, posteriorly, is narrowly crescentic whereas that of *P. penita* is sharply pointed and that of *P. gabbi* is acutely rounded.

A species in Japan, formerly referred to *P. penita*, was renamed *P. chishimana* by Habe (1317). The oriental species is said to differ from the California form in that the posterior end is not truncated and the growth lines are undulated. Records of Recent and perhaps fossil (1318) forms from Japan and possibly some from the north Pa-

cific cited under the name of *P. penita* may be referable to *P. chishimana* or other species.

FAMILY TEREDINIDAE RAFINESQUE (1319)

Much has been written concerning members of the family Teredinidae because of damage resulting from their habit of boring wood thus wreaking destruction upon wooden ships, pilings, or other structures.

A recent illustrated catalogue of the Teredinidae by Turner (1920) is indispensable to anyone working with this group of organisms.

["*Xylotrya*" sp.]

"*Xylotrya*, sp. indet. Tube only.", Dall, Proc. Calif. Acad. Sci., Vol. 5, p. 296, 1874. "well at San Diego," Pliocene. — Orcutt, West Amer. Sci., Vol. 6, Whole No. 46, p. 85, 1889. Dall's record (1874) cited. — Orcutt, quoted by Ellis and Lee, U. S. G. S., Water Supply Paper 446, p. 59, 1919. Dall's record (1874) cited. — Hertlein and Grant, Mem. San Diego Soc. Nat. Hist., Vol. 2, p. 48, 1944. Dall's record (1874) cited. Specimen. — Probably lost in the earthquake and fire of 1906.

Occurrence in the San Diego Formation.—San Diego well (Dall).

Remarks. — The sole record, repeated by later authors, of "*Xylotrya*, sp." from the San Diego well, is that of Dall in 1874. No further information is available concerning the tube upon which this record was based.

Xylotrya Leach of authors (non Leach in Menke, 1830), was referred to the genus *Bankia* Gray by Clench and Turner (1946, p. 8). The type species of *Bankia* is *Teredo bipalmulata* Lamarck.

A paper by Clench and Turner (1921) contains an excellent discussion accompanied by many pertinent references dealing with the members of the genus *Bankia* in the western Atlantic.

Xylotrya Leach in Menke, 1830, was placed by Turner 1955, in the synonymy of *Xylophaga* Turton, family Pholadidae subfamily Xylophaginae.

Under the current rules of the International Commission on Zoological Nomenclature *Xylophaga* Turton 1822 (1322), type, *X. dorsalis* Turton, is not preoccupied by *Xylophagus* Meuschen, 1788, and the name *Xylotomea* Dall, 1898 (1323) suggested as a possible substitute, is not needed because Meuschen's work has been rejected for nomenclatural purposes by the Internat. Comm. Zool. Nomencl., Opinion 260.

It seems possible that the fossil tube from the San Diego well may be referable to one of the genera of Teredinidae now occurring in west American waters. Any further remarks concerning it at the present time would be sheer speculation.

SUBCLASS ANOMALODESMATA DALL (1324) ORDER EUDESMONTIDA COX (1325)

SUPERFAMILY PANDORACEA RAFINESQUE (1326)

Shell usually of medium size, thin, with a nacreous inner layer (except Thraciidae), with or without a periostracum; right valve flat, the left convex; hinge with chondrophore and buttresses, sometimes with a lithodesma; pallial sinus lacking in some families, present in others. Late Triassic to Recent.

FAMILY PANDORIDAE RAFINESQUE (1327)

Shell compressed, inequivalve, free, solid, with nacreous and prismatic layers; the dorsal edges of the valves overlapping but not socketed, with dentiform crural ridges on either side of the resilium, but no true teeth; ligament amphidetic, external, obsolete; resilium internal, opisthodetic, usually reinforced on its anterior surface by a medial elongate lithodesma; area none; valves closed. beaks entire, pallial line simple. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 3, p. 532, 1895). Eocene to Recent.

A pallial sinus is lacking in this group. The pallial line is marked by a fine line of small scars extending in an arc between the two adductor impressions.

GENUS PANDORA HWASS

Pandora Hwass in Chemnitz, Neues Syst. Conchyl. - Cab., Bd. 11, p. 211, 1795. *Tellina inaequalvis* and *T. crystallina* cited. — Bruguière, Encycl. Method., Vers Testaces, Vol. 2, pl. 250, figs. 1a-c, 1797. (Genus name only.) — Lamarck, Mém. Soc. Hist. Nat. Paris, An VII, p. 88, 1799. Sole species, *Tellina inaequalvis* Linnaeus. — Boss and Merrill, Johnsonia, Vol. 4, No. 44, p. 189, 1965. "type species my monotypy, Lamarck, 1799, *Tellina inaequalvis* (Linnaeus)."

Calpodium Röding in Bolten, Mus. Bolt., p. 166, 1798. For *C. albidum* Bolten, in synonymy of which was included *Tellina inaequalvis* with reference to Chemnitz, Conchyl. - Cab., Vol. 6, pl. 11, figs. 106, a, b, c, d. [= *Tellina inaequalvis* Gmelin.] — Winckworth, Jour. Conch., Vol. 20, No. 2, p. 52, 1934.

Type species (designated by Children, Quart. Jour. Sci., Vol. 14, p. 302, January, 1823). — "*P. rostrata* (*Tellina inaequalvis* Linn.)" [= *Solen inaequalvis* Linnaeus, Syst. Nat., ed. 10, p. 673, 1758. "Habitat in M. Mediterraneo." Also illustrated by Hanley, Ipsa Linnaei Conchylia, pl. 1, fig. 6, 1855. — Sowerby, Reeve's Conch. Icon., Vol. 19, *Pandora*, sp. 2, pl. 1, figs. 2a, 2b, 1874. "Hab. Great Britain." See Dodge, Bull. Amer. Mus. Nat. Hist., Vol. 100, Art. 1, p. 46, 1952. — Allen, M. F., and Allen, J. A., discussed the habits of this species (Proc. Malacol. Soc. London, Vol. 31, Pts. 5 and 6, pp. 175-185, figs. 1-5 in text, December 30, 1955.)

Range. — Eocene to Recent in Europe; late Oligocene (San Ramon) or early Miocene to Recent in North America. Recent from the littoral zone to 1902 meters (1040 fathoms).

Description. — Shell inequivalve, thin, pearly inside; valves close, attenuated, behind; right valve flat, with a

diverging ridge and cartilage-furrows; left valve convex, with two diverging grooves at the hinge; usually no ossicle; pallial line slightly sinuated. Outer layer of regular vertical, prismatic cells. (Tryon, G. W., Jr., *Structural and Systematic Conchology*, Vol. 3, p. 143, 1884.)

Remarks. — Three species of *Pandora* have been recorded occurring in strata of Pliocene age in California, one of which occurs in the San Diego Formation.

Recent members of this genus are world wide in distribution but they are most abundant in cold or cool temperate waters. Eight species have been recorded as occurring at the present time in marine waters between the Bering Sea and San Diego, California. The extreme range in depth cited for these species is 5 to 369 meters (3 to 202 fathoms), but the average depth appears to be about 46 to 91 or 137 meters (25 to 50 or 75 fathoms). About a dozen species are living in tropical and subtropical west American waters.

A recent paper by Boss and Merrill (1928) deals with the members of the Pandoridae in the western Atlantic and a catalogue of this family was published recently by the former author (1929)

Key to Subgenera of *Pandora* (1930)

- A. Right valve with 2 teeth or crural laminae.
 a. *Lithodesma* present; right valve with radial markings *Pandorella*
 aa; *Lithodesma* lacking; right valve smooth or with growth lines only *Pandora* s. s. (1931)
- B. Right valve with 3 teeth or crural laminae; *lithodesma* present *Heteroclidus*

SUBGENUS *PANDORELLA* CONRAD

Pandorella Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 14, p. 572, 1862 (issued February 17, 1863). Sole species, "*P. (Pandora) arenosa*, C [onrad]." — Vokes, Jour. Paleo., Vol. 30, No. 3, p. 763, 1956. — K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 76, 1958. — Boss and Merrill, *Johnsonia*, Vol. 4, No. 4, p. 199, 1965. *Kennerlia* Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 602, 638, August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 88, 124, 1872. — Stoliczka, Mem. Geol. Surv. India, Palaeont. Indica, Ser. 6, Vol. 3, pp. XVI, 61, 1871. "*Pand. (Kenn.) bicarinata*, Carpenter, is the type of the sub-genus."

Type species (by monotypy). — *Pandora arenosa* Conrad [Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 130, 1834. "Locality. Yorktown, Va." Miocene. See also Gardner, U. S. G. S., Prof. Paper 199-A, p. 45, pl. 10, figs. 16, 19, 20, 1948 (as *Pandora (Kennerlia) arenosa* Conrad). See also Boss and Merrill, 1965, p. 200, pl. 122, figs. 1, 2; pl. 125, fig. 3.]

Range. — Miocene to Recent.

Description. — Like *Pandora*, s. s., but with a *lithodesma*; right valve with fine but widely spaced and some-

what irregular radial striae. (Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 260, 1931, for *Kennerlia* Carpenter.)

Remarks. — Adequate reasons for replacing *Kennerlia* by the earlier *Pandorella* were given by both Vokes and by K. V. W. Palmer.

Dall, 1921, listed seven species and subspecies of this subgenus living in the eastern Pacific between Bering Sea and San Diego, California, and three or four species have been reported in the Panamic fauna. Four Recent species were reported from the western Atlantic by Boss and Merrill.

Pandora (Pandorella) bilirata Conrad

Plate 47, Figure 1; Plate 48, Figures 14, 17, 18

Pandora bilirata Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 7, No. 7, p. 267, May 1855. — Conrad, U. S. Pacific Railroad Expl., Vol. 6, Pt. II, Geol. Rept., No. 2, p. 73, pl. 5, fig. 25, 1857. "Santa Barbara, Cal." [Probably Pleistocene according to Keen and Benton, Geol. Soc. Amer., Spec. Papers No. 56, p. 80, 1944.] — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 89, pl. 53, figs. 8, 9, 1924 (under subgenus "*Kennerlyia*"). "Range. Forrester Island, Alaska, to Point Abrejos, Lower California." Recent. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 261, 1931. Various localities, Pleistocene and Recent.

Type specimen. — Location of the type specimen not known to the present authors.

Type locality. — "Locality. — Occurs with the preceding" [which is *Cemoria crucibuliformis* Conrad from "Locality, California. Dr. Heermann."]

Range. — Middle Pliocene to Recent. Recent from Drier Bay, Prince William Sound, Alaska, to Point Abrejos, Lower California, in 18 to 260 meters (10 to 142 fathoms).

Occurrence in San Diego Fm. — L.A.M. Loc. 305.

Original description. — Oblong, very inequilateral, contracted anteriorly, convex medially; posterior side with two distant carinated lines towards the hinge margin which is straight and not oblique; posterior extremity truncated. (Conrad.)

Remarks. — One right valve and two (one a fragment) left valves of *Pandora bilirata* are present in the collection from Loc. 305 (LAM). The larger valve is 13 mm long. This is the first record of the occurrence of this species in the San Diego Formation. Faustman (1932) reported it from the Rio Dell Formation, of middle Pliocene age, in Humboldt Co., northern California.

A similar species, *Pandora pseudobilirata* Nomura and Hatai (1933), occurs in Japanese waters. This Japanese form was described as differing from *P. bilirata* in the less prominent submarginal ridges on the posterior area.

SUBGENUS *HETEROCLIDUS* DALL

Heteroclidus Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1518, October, 1903.

Type species (by original designation). — "Type

Clidiophora punctata Conrad."

Range. — Miocene (1334) to Recent.

Original description. — Like *Clidiophora*, but the long left posterior lamina absent, the right posterior lamina short, and the low anterior right lamina produced; both the anterior laminae end in front of the anterior adductor scar; lithodesma present. (Dall.)

Pandora (Heteroclidus) punctata Conrad

Plate 42, Figures 2, 3, 9, 10

P[andora]. punctata Conrad. Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, Pt. 2, p. 228, pl. 17, fig. 1, 1837. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 90, pl. 53, figs. 6, 7, 1924. Specimens illustrated from San Diego, California, Recent. — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 262, pl. 13, figs. 2a, 2b, 1931. Specimen illustrated from "upper San Pedro (Palos Verdes), upper Pleistocene of San Pedro." Also earlier records cited, ?Miocene to Recent. — Woodring, in Woodring and Bramlette, U.S.G.S., Prof. Paper 222, p. 91, pl. 17, fig. 13, 1950. Graciosa Member of Careaga Santone; "cf." in Cebada Member, Santa Maria district, California, Pliocene. — Morris, A Field Guide to Shells of the Pacific Coast and Hawaii (Houghton Mifflin Company: Boston), pp. 25, 61, pl. 8, fig. 11, 1952. Vancouver Island to the Gulf of California, Recent.

Clidiophora punctata Conrad, Arnold, Smithsonian Misc. Coll. (Quarterly Issue), Vol. 50, Pt. 4, pp. 4, 27, pl. 56, figs. 2, 3, 1907. "Graciosa Ridge, near Orcutt," California, Pliocene. — J. P. Smith, Proc. Calif. Acad. Sci., Ser. 4, Vol. 3, p. 171, p. 181 (type error, as *Clidiophora punctata*), 1912. "San Diego-Purisima," Pliocene.

Pandora (Heteroclidus) punctata Conrad, Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 226, fig. 574, 1958. British Columbia to the Gulf of California, Recent.

Type specimen. — British Museum (Natural History). "1 valve, probably figured holotype" (A. M. Keen, Veliger, Vol. 8, No. 3, p. 172, 1966).

Type locality. — "Inhabits in the neighborhood of Sta. Barbara. Single valves occur on the beach at the recess of the tide."

Range. — Middle Pliocene to Recent. Recent from Vancouver Island, British Columbia, to Cape San Lucas, Lower California. (Keen.) From below low tide to a depth of 46 meters (25 fathoms).

Occurrence in San Diego Fm. — C.A.S. Loc. 957, 1178, 1400. L.A.M. Loc. 305C. S.D. Loc. 21. U.C.L.A. Loc. 1386.

Original description. — Shell much compressed; posterior side produced, extremity rostrated, truncated; ligament margin recurved, sub-margin carinated; within punctate; cardinal teeth three in the superior valve; in the inferior, one elongated oblique tooth. Length, one and a half inches. [Length refers to the largest specimen (footnote).] (Conrad.)

Remarks. — Several excellently-preserved specimens of this species are present in collections from the upper part of the Pliocene section at Pacific Beach. The largest

specimen from Loc. 1178 (CAS) is 43 mm long, 23.5 mm high (ventral margin slightly imperfect), the convexity (both valves together), 5.9 mm. Another specimen from Loc. 21 (SD), is 41.2 mm long, 24.6 mm high, convexity (both valves together), 7.6 mm. One of the largest Recent specimens in the collection of the California Academy of Sciences, from Coronado Beach, California, is 45.5 mm long. The fossils agree in all observable characters with Recent specimens of *Pandora punctata* from San Diego. This species also has been recorded from various localities in southern California in beds of Pliocene and Pleistocene age.

The form of *P. punctata* described as "var. *Gabbi* Dall" (1935) from beds of supposed Miocene age was said to differ from *P. punctata* in that it lacks the interior punctations characteristic of the typical form. Woodring (1950) mentioned that rarely Recent shells have no punctae.

FAMILY PERIPLOMATIDAE DALL (1936)

Shell subnacreous, conspicuously inequivalve, nearly closed, edentulous; the resilium internal, between two anteriorly or vertically directed chondrophores, often buttressed, the lithodesma rarely wanting; ligament and area absent; the beaks fissured, the pallial sinus broad and shallow; monoecious; marine. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 3, p. 531, 1895.) Late Cretaceous to Recent.

Lamy (1937) published a paper dealing with many of the Recent species of this family, and three new generic names in the Periplomatidae of Australia were proposed by Iredale (1938). Rosewater (Amer. Malacol. Union, Ann. Repts. for 1968, pp. 37-39) recently presented an outline of the classification of this family.

GENUS PERIPLOMA SCHUMACHER

Periploma Schumacher, Essai Nouv. Syst. Habit. Vers Test. pp. 115, 116, 1817. Sole species, *Periploma inaequivalvis* Schumacher. — Dall, Bull. Mus. Comp. Zool., Vol. 12, No. 6, p. 305, 1886. Type *P. inaequivalvis* Schumacher. — Lamy, Jour. de Conchyl., Vol. 75, No. 4, p. 303, 1931. "Qui a pour type *P. inaequivalvis* Schum. = *Anatina trapezoides* Lk. = *Corbula margaritacea* Lk."

Type species (by monotypy). — *Periploma inaequivalvis* Schumacher, 1817, pp. 115, 116, pl. 5, fig. 1. [For references to this species see Lamy, 1931, pp. 304-305.]

Range. — Late Cretaceous to Recent, mostly in warmer waters. Recent in from 7 to 2295 meters (4 to 1255 fathoms).

Description. — Shell suborbicular to elongate-ovate, beaks opisthogyrate, the posterior side typically narrower and shorter. Distinguishing character of the genus is the large chondrophore found in each valve, strengthened below and behind by a rib or clavicle soldered to the wall of the shell. Lithodesma, as described above, is seen only in specimens with tightly closed valves. Surface minutely

granulose, most heavily so on the posterior slope, often faint or absent elsewhere. Surface with plain sculpture of growth lines, or with concentric undulations as in *Cyathodonta*, or strongly radially ribbed. (Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 460, 1961.)

Remarks.—Seven species of *Periploma* have been recorded from strata of Tertiary age in California. About the same number of species now live in west American waters between Monterey Bay, California, and Peru, only two ranging into California waters.

Key to Species of *Periploma*

- A. Beaks nearly centrally located *stenopa*
 B. Beaks decidedly nearer the anterior end . . . *planiuscula*

Periploma cf. *P. planiuscula* Sowerby

The following references to the literature, type specimen, type locality, range and description, refer to typical *P. planiuscula*.

Periploma planiuscula Sowerby, Proc. Zool. Soc. London, for 1834, p. 87, issued October 25, 1834. — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 82, pl. 22, fig. 1, 1924. "San Pedro, California, to Guayaquil, Ecuador. In the Pleistocene at San Pedro and San Diego, California." — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 225, pl. 13, figs. 1a, 1b, 1931. Pliocene to Recent. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press), p. 229, fig. 585, 1958 (as *Periploma planiusculum*). "Southern California to Peru, from the extreme low tide level to depths of a few fathoms."

Periploma (*Periploma*) *planiuscula* Sowerby, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 463, pl. 82, figs. 2, 2a-e, 1961. Southern California to northern Peru.

Type specimen. — Location unknown to the present authors.

Type locality. — "Hab. ad Sanctam Elenam." Ecuador.

Range. — Middle Pliocene to Recent. Recent from San Pedro, California, to Negritos, Peru, from extreme low tide to a few meters.

Occurrence in San Diego Fm. — L.A.M. Loc. 305.

Original description. — Per. testâ oblongâ, planiusculâ, inaequali, albicante, impolitâ, tenuiusculâ; latere antico brevi, subrugoso; marginibus, antica subdeclivi subtruncatâ, dorsali rectiusculâ; epidermide tenui, pallescente: long., 2.4, lat. 0.8, alt. 1.8 poll. (Sowerby.)

Remarks. — Several fragments of a *Periploma*, the largest about 13 mm long, revealing only the hinge area retaining the chondrophore, are present in the collection from Locs. 305 and 305A (LAM). These agree so well with the corresponding portions of *Periploma planiuscula* Sowerby that we refer them, provisionally, to that species. Sowerby's species is well known in the Pliocene and Pleistocene of southern California and has been reported

from strata of Pliocene age in Cosa Rica, Panama, and Ecuador. Recent specimens 47 mm long and 29 mm high have been reported from Costa Rica (see Min. Conch. Club South. Calif. No. 190, p. 21, 1959).

Periploma sanctaecrucis Arnold (1339), a species of late Miocene or Pliocene age, is a possible precursor of *P. planiuscula*.

Periploma teevani Hertlein and Strong (1340) is similar to *P. planiuscula* but the shell is higher in proportion to the length. Furthermore, the rows of pustules on the exterior of the valves are arranged in radial rows rather than the irregular arrangement on *P. planiuscula*.

Periploma venezuelana wiedenmayeri H. K. Hodson (1341) with irregular arrangement of pustules is a Venezuelan Miocene subspecies similar to *P. planiuscula*.

Periploma stenopa Woodring Plate 41, Figures 6, 7

Periploma cryphia stenopa Woodring, U. S. G. S., Prof. Paper 190, p. 57, pl. 9, fig. 7, 1938.

Type specimen. — No. 496106, United States National Museum.

Type locality. — "Union Oil Co. Hellman No. 18 Dominguez field, depth 4,076 feet (U. S. G. S. locality 13899)". Repetto Formation, early Pliocene.

Range. — Early Pliocene (Repetto Formation) to middle Pliocene.

Occurrence in San Diego Fm. — L.A.M. Loc. 305A.

Original description. — Larger and more elongate than *cryphia* proper and having a more pointed posterior end. Length 45.2 millimeters, height 33.9 millimeters (holotype). (Woodring.)

Remarks. — Four specimens of a *Periploma*, varying in the degree of preservation, are present in the collection from Loc. 305A (LAM) near the Mexican boundary.

The best preserved of these, apparently slightly flattened and the anterior dorsal margin imperfect, is 55.5 mm long, 49.3 mm high, and the convexity (both valves together), 16.5 mm. The shape and shell characters of the four specimens agree so well with the original description and illustration of "*Periploma cryphia stenopa*" Woodring that we identify them with that form which we consider to be a distinct species.

The outline of this species is ovately elongate, the shell is thin, the beaks nearly centrally located along the dorsal margin are fissured as is often the case with fossil specimens of this genus. The anterior end and ventral margin are rounded. The posterior dorsal margin is nearly straight and merges into the obliquely rounded posterior end. A slightly depressed but distinct posterior dorsal area is present. Sculpture consists of fine concentric lines of growth.

One specimen is 56.5 mm long, 39.4 mm high, the convexity (both valves together) 16.4 mm. Another one is 40.6 mm high, the convexity (both valves together) 20 mm.

The present species differs from *Periploma cryphia* Woodring (1342) in the more obliquely rounded posterior end and apparently in the larger flattened posterior area. None of the elongate species of *Periploma* living along the Pacific coast have the beaks as centrally placed as on this

fossil form.

Cochlodesma leana floridana Mansfield (1343), a species of late Miocene age in Florida, 58 mm long, has a more steeply sloping posterior dorsal margin and a less flattened posterior area than that of *P. stenopa*.

The elongate shape and nearly centrally placed beaks of the present species in general are similar to those characters on some species of the genus *Cochlodesma* Couthouy (1344). That genus has a broad, blunt buttress to the chondrophore and below it a very thin supplementary one. This is different from the long thin buttress which Woodring stated is present on *P. eryphia*. Until the character of the buttress of *P. stenopa* is known to be referable to some genus other than *Periploma*, it seems best to leave it in the genus under which it was originally described.

FAMILY THRACIIDAE STOLICZKA (1345)

Shell earthy and cellulo-crystalline, not nacreous; inequivalve, thin, edentulous, often with a granular surface; ligament and resilium chiefly external, opisthodontic, parivincular, seated on posteriorly directed nymphae; area none, beaks usually entire; nearly closed valves, pallial sinus present. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 3, p. 531, 1895.) Jurassic to Recent.

Remarks. — The members of this family occur at the present time in all seas. Some nestle in holes in rocks or in other available cavities whereas others occur on mud to depths of 3600 meters (1968 fathoms), but usually in shallower water.

A paper by Lamy (1346) deals with the Recent species of Thraciidae in the Natural History Museum in Paris and a paper by Soot-Ryen (1347) contains a good discussion of the north European species in this family. A paper by Allen (1348) contains the results of a careful study of the British species of *Thracia*.

Key to Genera of Thraciidae

- A. Shell ornamented by prominent oblique concentric undulations;
granulose *Cyathodonta*
- B. Shell ornamented only by fine concentric lines of growth; often with fine granulation; texture often earthy . . . *Thracia*

GENUS THRACIA LEACH

Thracia Leach in Sowerby, Min. Conch., Vol. 5, No. 72, p. 20, July 1, 1823. [No species cited.] — Blainville, Dict. Sci. Nat., Vol. 32, p. 347, 1824. Species cited: division "A" with "*Thracia corbuloidea*" and division "B" with "*T. pubescens* Leach *Mya pubescens* Linn." — Arkell, Palaeontogr. Soc. London, Vol. 89, British Corall, Lamell., Pt. IX, p. 354, 1936. "Type: *Mya pubescens* Linné." — Vokes, Jour. Paed., Vol. 30, No. 3, p. 763, 1956.

Type species (designated by Anton, Verzeichniss der Conchylien, p. 2, 1839). — *Thracia "pubescens" Lam.* [= *Mya pubescens* Pultenye, Cat. Birds, . . . Shells, . . . Plants, . . . Dorsetshire, ed. 1, p. 27, 1799. "Dredged up at Weymouth" [Weymouth]. For synonymy and references to this species see Lamy, Jour. de Conchyl., Vol. 75, No. 3, pp. 217-220, 1931. England to the Mediterranean, Senegal, and Canary Islands. Good illustrations of this species were published by Soot-Ryen, Tromsø Mus. Arshefter (Naturhist. Avd. Nr. 17), Vol. 61, No. 1, pl. 5, figs. 1, 2; pl. 7, fig. 4; pl. 9, fig. 8 a-c, 1941.]

Range. — Typical *Thracia*, Eocene to Recent and perhaps Triassic to Recent. Recent in from 5 to 3600 meters (3 to 1968 fathoms).

Description. — Shell concentrically striated, with more or less fine superficial granulation and a very delicate periostracum; subrostrate, slightly gaping behind; slightly inequivalve, the right valve larger; the beaks in contact and usually perforated by friction on each other, the hinge-plate fissured below them and edentulous; the ligament external, the resilium more or less sunken and with, in most cases, a short, transverse lithodesma in front of it, occupying the fissure in the hinge-plate; pallial line with a moderate sinus, margins of the valves entire; the nymphs in the typical forms do not project greatly from the hinge-margin ventrally and more or less elongated; the shell is destitute of naere. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1523, 1903.)

Remarks. — Blainville was the first author to assign species to the genus *Thracia* in 1824. He proposed two divisions, "A" with a chondrophore in one valve, represented by *T. corbuloidea*, and the other "B" with a chondrophore in each valve, represented by *T. pubescens*. Later Blainville (1349) stated that his division "B" should be suppressed because the species which he cited was not correctly identified. This procedure, if valid, would leave *T. corbuloidea* as type of *Thracia*, as stated by Keen (1350). However, under the Internat. Rules Zool. Nomencl., such action by an author has no validity in nomenclature.

Anton, 1839, designated *Thracia pubescens* "Lam." as type species of *Thracia*. Although he attributed this species to Lamarck, rather than to Pulteney, his designation of type species is the earliest for this genus. Deshayes (1351), 1830, evidently considered this same species (attributing it to Linnaeus) to be the type of *Thracia* but he did not definitely so designate it.

Four species of *Thracia* have been recorded from strata of Pliocene age in western North America and a new species here described occurs in the San Diego Formation. About an equal number have been described from pre-Pliocene strata in the same region. Eight species have been reported living in west American waters between the Bering Sea and northern Peru.

A paper by Kamada (1352) dealing with the Tertiary species of *Thracia* in Japan appeared recently. Some of these Oriental species are similar to west American Tertiary forms.

Thracia kanakoffi n. sp.

Plate 42, Figures 11, 13, 14, 15

Description. — Shell large, thin, valves slightly

unequal, nearly equilateral, moderately convex; anterior margin sloping rather steeply and rounding into the broadly rounded base, the posterior dorsal margin sloping very gently downward to the slightly rounded truncated posterior end; a well-developed umbonal ridge delimits the posterior end; anterior to this is a well developed radial depression on the right valve but on the left valve a corresponding depression is much less developed; a narrow but distinct ridge is present just below and diverging slightly from the posterior dorsal margin on the right valve; sculpture consisting of incremental lines of growth, a few slight concentric furrows on the umbos, and over most of the shell especially toward the base, granulations are rudely concentrically arranged except toward the ventral margin where they may assume a rude radial arrangement; on the posterior dorsal area the rows of granulations often coalesce to form beaded threads which are rudely concentric but sometimes form interlacing patterns. Dimensions of holotype: length, 81 mm, height, 54.2 mm, convexity (both valves together) 32 mm, beak approximately 39 mm from anterior end.

Type specimen. — Holotype and two paratypes from Loc. 291 (LAM), silt beds exposed in a gully in the center of the south half of Sec. 27, T. 4 N., R. 15 W., San Bernardino Base and Meridian; one half mile south of the Humphrey railroad station, Los Angeles Co., California; Pico Formation, middle Pliocene.

One paratype is 93 mm long, 70.4 mm high, convexity (both valves together) 38 mm. The other in which the hinge of the right valve is exposed is 93 mm long and 68 mm high. On a specimen 96.5 mm long, the pallial sinus extends anteriorly 39 mm, on another specimen 74 mm long the pallial sinus extends anteriorly 34 mm from the posterior end of the valve.

Occurrence in San Diego Fm. — C.A.S. 1419. L.A.M. 107, 305. S.D. 34.

Remarks. — Over fifty specimens from the type locality have been available for study. These range in length from 5 mm to 96.5 mm. The hinge, where exposed, appears to be that of typical *Thracia*.

This new species bears considerable resemblance to *Thracia trapezoides* Conrad (1353) but it differs in the less steeply sloping posterior dorsal margin, in the presence of a narrow ridge just below and gently diverging from the posterior dorsal margin of the right valve, and in the less developed radial depression just anterior to the posterior umbonal angulation on the valves.

The present form attains a huge size. A cast, somewhat compressed, lacking the shell, from Loc. 107 (LAM) is 132 mm long and 86 mm high.

The largest specimen of *Thracia trapezoides* from Puget Sound in the collection at Stanford University is 67 mm long. The largest specimen of the latter species among a series from the Timm's Point Formation, Loc. 130-7 (LAM), of late Pliocene or early Pleistocene age, is 60.4 mm long. This species is reported living in west American waters from Craig, Alaska, to Redondo Beach, California, in 64 to 173 meters (35 to 75 fathoms), in mud.

Thracia kakumana Yokoyama as illustrated by Kamada (1354) from strata of Pliocene age in Japan attains a length of 80 mm. It bears a resemblance to *T. kanakoffi* n. sp., but the anterior end is more broadly rounded and the surface of the valves is said to lack granulation.

This new species is named for George P. Kanakoff, formerly Curator of Invertebrate Paleontology, Los Angeles County Museum, who made an extensive collection of Pliocene fossils in the San Diego area and who generously made this material available for the present monograph.

GENUS *CYATHODONTA* CONRAD

Cyathodonta Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 4, p. 155 1849. Sole species, *Cyathodonta undulata* Conrad. — Lamy, Jour. de Conchyl., Vol. 75, No. 3, p. 215, 1931. "Type: *T. undulata* Conr." — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 459, 1961. "Type species by monotypy, *Cyathodonta undulata* Conrad."

Type species (by monotypy). — *Cyathodonta undulata* Conrad [Proc. Acad. Nat. Sci. Philadelphia, Vol. 4, p. 156, 1849. Title of article states, "Shells are from the coasts of Lower California and Peru." "East coast of Lower California," designated as type locality by Hertlein and Strong (Zoolgica, Vol. 31, Pt. 3, No. 8, p. 96, December 5, 1946). Illustrated by Keen, Sea Shells of Tropical West America (Stanford Univ. Press), p. 232, fig. 595 (on p. 233), 1958. Southern part of the Gulf of California to Peru.]

Range. — Oligocene to Recent. Recent in from 22 to 73 meters (12 to 40 fathoms), and perhaps deeper.

Description. — Shell broadly ovate to subrectangular, the anterior side longer, rounded, the posterior side shorter, depressed, and subtruncate; beaks entire, not fissured by contact with each other; cardinal plate not fissured; ligamental myophores short, rounded, projecting with a thin, semicircular lithodesma suspended vertically in front of them. Surface sculptured with strong concentric, sometimes oblique, wave-like plications or undulations; surface granulose. (Adapted from Lamy, 1931 (free translation), and Olsson, 1961.)

Remarks. — The shell of *Cyathodonta* differs from that of *Thracia* in the strong, obliquely concentric corrugations of the valves and in the strongly granulose surface, the granules often arranged in a definite pattern.

The first appearance of this genus in west American Tertiary strata is that of *Cyathodonta weaveri* Clark (1355) in the San Ramon Formation often assigned late Oligocene age, in west central California. Species also have been recorded from beds reported to be of Oligocene age in Mississippi and Porto Rico and in beds of Miocene age in the Caribbean region, in Costa Rica, and in Panama. "*Cyathodonta* sp." has been recorded from beds of late Miocene age (Neroly) in southern California by Eaton, Grant, and Allen (1356). This genus also is present in beds of Pliocene and of Pleistocene age in southern California and in Lower California and in the Pleistocene of Panama.

Five, possibly six, species and subspecies live in west American waters between Monterey, California, and Peru, and the Galápagos Islands. Two of these range north into southern Californian waters.

Cyathodonta sp.

Occurrence in San Diego Fm. — L.A.M. 104, 305.

Remarks. — A species of *Cyathodonta* is represented by several fragments at Loc. 305 (LAM). A fragment of a right valve, 10.8 mm long, retains the hinge area. The chondrophore on this and on other fragments projects downward at an angle of about 45°. In this character as well as in the numerous rather fine concentric corrugations on the umbo, the fragment resembles *Cyathodonta formosa* Nomland (1937) described from upper Etchegoin Pliocene beds in the San Joaquin Valley. The fragmental character of the specimens is such as to preclude positive specific identification.

A portion of a small valve about 10 mm long is exposed in matrix from Loc. 104 (LAM). The corrugated concentric sculpture of the shell is similar to that of *Cyathodonta* but the species represented is open to question.

ORDER POROMYOIDA PELSENEER
SUPERFAMILY POROMYACEA DALL
FAMILY POROMYACIDAE DALL (1938)

Shell small, thin, rounded or cordate, subequilateral, umbos central, prosogyrate, posterior side sometimes angulated, valves closed or nearly so, the interior pearly; exterior with rows of granules or smooth; ligament external, opisthodontic; resilium sub-internal below the ligament, seated upon a chondrophore, a small lithodesma present; hinge of right valve with a stout cardinal tooth behind and above chondrophore in typical genus but teeth nearly obsolete in the adults of some genera; muscle impressions subequal, suborbicular, the posterior one slightly smaller; pallial sinus small or lacking. [Adapted from Dall, Eastman's ed. of Zittle's Textbook of Paleontology, Vol. 1, p. 469, 1913, and Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 466, 1961.] Cretaceous to Recent.

Remarks. — The majority of the members of this family live in deep water, but a few occur no deeper than 55 meters (30 fathoms). These mollusks occur rather rarely as fossils.

Dall (1939) discussed the systematics of this family and mentioned the characters by which various supra-specific units may be separated.

GENUS *DERMATOMYA* DALL

Dermatomya Dall, Bull. Mus. Comp. Zool., Vol. 18, pp. 448 et seq., 452, May 20, 1889. Sole species, *Poromya (Dermatomya) mactroides* Dall. — Dall, Proc. U.S. Nat. Mus., Vol. 12, No. 773, pp. 289, 291, 1889 (issued March 7, 1890). — J. Q. Burch, Min. Conch. Club South. Calif., No. 38, p. 11, August-September, 1944. "Type (by monotypy) *Dermatomya mactroides* Dall 1889. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), pp. 466, 467, 1961.

Type species (by monotypy). — *Poromya (Dermatomya) mactroides* Dall [Bull. Mus. Comp. Zool., Vol. 18, p. 448, May 20, 1889. "It was dredged by the Albatross off the coast of Ecuador, in 741 fms." — Dall, Proc.

U.S. Nat. Mus., Vol. 12, No. 773, p. 291, pl. 8, fig. 8, 1889, issued March 7, 1890 (as *Dermatomya mactroides*). — Dall, Bull. Mus. Comp. Zool., Vol. 43, No. 6, p. 429, 1908 (as *Poromya (Dermatomya) mactroides*). Type specimen said to be the one illustrated in 1889 (1890). Off southern Chile or western Patagonia in 122, 348, 449 fathoms. See discussion below under Remarks].

Range. — Middle Pliocene to Recent in eastern Pacific and Japan, in 55 to 3058 meters (30 to 1672 fathoms), and perhaps deeper.

Description. — Shell small, subovate, subequilateral, sometimes angulated posteriorly; umbos central, usually somewhat inflated, prosogyrate; exterior sculptured only with concentric lines of growth; hinge of right valve with a stout subumbonal cardinal tooth in front of a rather wide chondrophore; hinge of left valve with a notch which received the cardinal in the opposite valve, a small cardinal tooth behind and above the chondrophore; pallial sinus well developed.

Remarks. — The genus *Dermatomya* is recorded here from the San Diego Formation for the first time. Previously it was reported from beds at Timm's Point, San Pedro, California, believed to be of Pleistocene age. The generally deep water habitat of members of this genus probably explains the paucity of fossil occurrences. Seven species live in the waters of the eastern Pacific between Alaska and Chile and one species or subspecies lives in Japanese waters.

The type species of *Dermatomya*, *Poromya (Dermatomya) mactroides*, was first briefly described by Dall May 20, 1889, and the locality cited off Ecuador in 741 fathoms. The following year a more extensive description and an illustration of the species was published and three localities were mentioned on the west coast of Patagonia and one off Ecuador. The length of the shell in the description and in the illustration was given as 18 mm. In 1908 Dall referred to this species, stated that the type was illustrated in 1889 [1890], that it was 10 mm long, and that it was a Patagonian species. The shell from Ecuador, 18 mm long, was described as a new species, *Poromya (Dermatomya) equatorialis*. In the explanation to the plate the specimen illustrated was indicated as 6.5 mm long rather than 18 mm as given in the description. The illustration is that of a shell on which the posterior end is more truncated and the posterior groove apparently more developed than that shown in the figure by Dall in 1889 [1890]. There is confusion in the records concerning the two species but this does not affect the conception of the genus *Dermatomya* because the shell characters of the two species are referable to the same supraspecific category.

The genus *Poromya* Forbes (1360) differs from *Dermatomya* in that the shell is sculptured with a series of radial rows of fine granules and it lacks a pallial sinus. *Poromya* is much more widely distributed both geologically and geographically than *Dermatomya*. It has been reported from Eocene to Recent. Species referred to this genus have been described which live in western Europe, in the Mediterranean, Atlantic, Caribbean, Antarctic, eastern Pacific, Japan, East Indies, India and East Africa. Lamy (1361) mentioned a number of species, Recent and fossil from various localities. Under the genus *Poromya*, including three subgenera, Odhner (1362) listed 48 taxa, Recent and fossil. Some of these are referable to other

genera.

One species, *Poromya perla* Dall, was described from the Gulf of Panama at a depth of 2323 meters (1270 fathoms).

The species described as *Poromya gabbiana* Anderson and Martin (1363) from beds of early Miocene age in San Luis Obispo County, California, was later assigned to the genus *Solecurtus* Blainville by Keen and Bentson (1364).

Tegland (1365) reported "*Poromya* n. sp." from the Blakeley Formation in western Washington which she believed to be of late Oligocene age. A fossil from the same area was described by Weaver, (1943, p. 121, pl. 25, fig. 23) under the name of *Poromya teglandae* but Addicott (1366) recently assigned that species to the genus *Macoma*.

Abbott (Nautilus, Vol. 65, No. 1, p. 33, 1951) pointed out that a Recent form described as *Poromya oregonensis* by Ridewood in 1903, with illustrations of the gills and internal organs only, and without information concerning the locality from which it came, "probably should be considered a *nomen dubium*".

Dermatomya tenuiconcha Dall
Plate 56, Figures 6, 7, 10, 11, 13

Poromya (Dermatomya) tenuiconcha Dall, Proc. U.S. Nat. Mus., Vol. 45, No. 2002, p. 596, June 11, 1913. *Poromya tenuiconcha* Dall, U.S. Nat. Mus., Bull. 112, p. 27, pl. 3, fig. 10, 1921 (under subgenus *Dermatomya*). "Alaska Peninsula to Coronado Islands, in deep water." — I.S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 95, pl. 54, figs. 24, 25, 26, 1924. Type locality and range same as cited by Dall.

Type specimen. — No. 266865, United States National Museum.

Type locality. — "In deep water off Monterey Bay, California."

Range. — Middle Pliocene to Recent. Recent from Alaska Peninsula to the Coronado Islands, Lower California, Mexico, in 50 to 133 meters (30 to 73 fathoms), one record of 1205 meters (659 fathoms) (see Burch, J.Q. Min. Conch. Club South. Calif., No. 38, p. 11, August-September, 1944; and Smith, A.G., and Gordon, M., Proc. Calif. Acad. Sci., Ser. 4, Vol. 26, No. 8, p. 172, 1948).

Occurrence in San Diego Fm. — L.A.M. Loc. 305.

Original description. — Shell small, thin, olivaceous, the pearly luster showing through the periostracum; equivalent, inequilateral, anterior end shorter, rounded in front; posterior end longer, roundly truncate; beaks prominent, prosocoelous, with a marked but uncircumscribed depression in the lunular region in front of them; interior pearly, brilliant; margins simple, sharp; hinge in the left valve with a small internal resilium seated on an inconspicuous oblique chondrophore, with a notch immediately in front of it, into which fits a projecting denticle on the corresponding part of the opposite valve. Height, 13; length of shell, 16; anterior portion, 6; diameter, 10 mm. (Dall.)

Remarks. — *Dermatomya tenuiconcha* is reported

here from the San Diego Formation for the first time. Two valves, probably paired, are 9.7 mm long, 8.2 mm high, the convexity (both valves together) 6.8 mm. A small specimen, 5.7 mm long, both valves adhering to each other, appears to be a juvenile form of this species.

This species is rather rare in collections of Recent shells and so far as we know it has been reported previously as a fossil only at Timm's Point, San Pedro, California, from strata which Clark (1367) considered to be of Pleistocene age. According to Burch, it is not uncommon in those beds.

The smooth posterior area, lacking a groove or a carina, serves to separate *D. tenuiconcha* from the tropical *D. equatorialis* Dall (1368).

A subspecies, *D. tenuiconcha soyoae* Habe (1369), described from Japanese waters, is more produced posteriorly than are typical forms of the west American shell.

Another form from Japan, *Dermatomya tenuiconcha sagamiensis* Okutani (1370), described as a questionable variety of the North American species, was said to differ from the latter in the "somewhat elongated shell, paler coloration and nearly horizontal chondrophore."

FAMILY CUSPIDARIIDAE DALL (1371)

Shell subequivalve, rostrate, earthy or cellulo-crystalline, rarely with surface granulations; hinge edentulous or with subumbonal desmodont tuberculation, sometimes buttressed; ligament subinternal, anterior to the beaks or obsolete; resilium internal, with a mesial or ventral lithodesma; area amphidetic or obscure; valves closed except at the tip of the rostrum; pallial line simple; the retraction of the siphons usually effected by the contraction of the septum, the latter leaving a scar on the valves resembling a pallial sinus. (Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 3, p. 536, 1895.) Cretaceous to Recent.

Remarks. — The family Cuspidariidae is represented in strata of Tertiary age in California by one genus with five species in the Eocene and two species in the Pliocene. The family is here reported for the first time from the San Diego Formation. In the Recent west American molluscan fauna 12 species, distributed in four supra-specific units, live in the region between the Bering Sea and San Diego, California, and three genera or subgenera containing six or eight species live in the tropical and sub-tropical waters in the eastern Pacific.

GENUS CUSPIDARIA NARDO

Neaera Griffith and Pidgeon, "The Mollusca and Radiata" in the Animal Kingdom arranged in conformity with its organization, by the Baron Cuvier, with supplementary additions to each order by E. Griffith and others (Whittaker and Company: London), Vol. 12, "*Neaera Chinensis*" on legend to pl. 22, fig. 5, on p. 598 as "*Neroea Chinensis*, Gray," plate dated 1833, whole volume issued 1834.

Not *Neaera* Robineau-Desvoidy, 1830. Diptera.

Cuspidaria Nardo, Ann. Sci. Regno Lombardo - Veneto,

Vol. 10, p. 50, 1840; Rev. Zool., p. 30, 1840. — Stewart, Acad. Nat. Sci. Philadelphia, Spec. Publ. No. 3, p. 307, 1930. Type, *Cuspidaria typus* Nardo. — Prashad, Siboga Exped., Pelecypoda, Monogr. 53c, p. 327, 1932. "The genotype is *Cuspidaria cuspidata* (Oliv.)." K.V.W. Palmer, Geol. Soc. Amer., Mem. 76, p. 78, 1958. Type by original designation *Cuspidaria typus* Nardo ms. = *Tellina cuspidata* Oliv.

Type species (by original designation, see Internat. Code Zool. Nomen., Art. 30, b). — *Cuspidaria typus* Nardo ms., Adriatic Sea [= *Tellina cuspidata* Oliv. Zoologia Adriatica p. 101, pl. 4, fig. 3 (A, B, C), 1792. Adriatic Sea, Recent. See also Deshayes, Traité Élém. Conchyl., Tom. 1, Pt. 2, p. 192, pl. 12 bis, figs. 6-8, 1843-1850 (as *Neaera cuspidata*) Mediterranean. — Kobelt, Illustr. Conchylienbuch, Bd. 2, p. 322, pl. 93, fig. 15, 1881 (as *Neaera cuspidata*). — Sacco, Moll. Terr. Terz. Piemonte e Liguria, Pt. 29, p. 123, pl. 26, figs. 31-34, 1901. Elveziano; Piacenziano; Astiano. — Dall in Zittel's Text-Book of Paleontology, ed. by Eastman (Macmillan Co.: London), p. 469, fig. 748, 1913. Austria, Miocene].

Range. — Jurassic to Recent. Recent, widely distributed from 26 to 7297 meters (14 to 3990 fathoms).

Description. — Shell small or of medium size, with a well-rounded, convex, anterior side and a narrowly produced posterior end. Hinge without cardinal teeth, the right valve having a strong, posterior, lateral tooth bordered above by a linear socket into which the margin of the left valve fits. Chondrophore is a narrow, spoon-shaped plate placed directly under the beak, directed slightly backward, and similar in both valves. Surface with concentric ribbing. (Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 465, 1961.)

Remarks. — Five species living in west American waters between the Bering Sea and San Diego, California, were reported under *Cuspidaria* s.s. by Dall in 1921. One species lives in deep water off Panama.

Conrad (1372) published a catalogue of the Recent species known to him in 1869. Kuroda (1373) more recently discussed the species of *Cuspidaria* living in Japan. Eleven species have been reported from that area.

SUBGENUS *CARDIOMYA* A. ADAMS

Cardiomya A. Adams, Ann. Mag. Nat. Hist., Ser. 3, Vol. 13, p. 208, March, 1864. — Eames, Philos. Trans. Roy. Soc. London, Ser. B, Biol. Sci., No. 627, Vol. 235, p. 453, 1951. Type by monotypy, *Neaera gouldiana* Hinds.

Type species (by monotypy). — *Cardiomya gouldiana* Hinds [= *Neaera gouldiana* Hinds, Proc. Zool. Soc. London for 1843, p. 77, December, 1843. "Hab. New Guinea; Cagayan, island of Mindanao; and Bay of Manila, Philippines: in from seven to thirty fathoms, sandy mud." — Hinds, Zool. Voy. Sulphur, Moll., Pt. 3, p. 70, pl. 20, fig. 17, 1845. — Chenu, Man. de Conchyl., Vol. 2, p. 50, fig. 208, 1862. — Kobelt, Illustr. Conchylienbuch, Bd. 2, p. 322, pl. 93, fig. 16, 1878].

Range. — Late Cretaceous to Recent. Recent, widespread, in 18 to 4380 meters (10 to 2395 fathoms).

Description. — Shell similar to that of *Cuspidaria* s.s.

but with sculpture of radial ribs and larger, more vertically directed chondrophore.

Remarks. — Most of the species described under the genus *Cuspidaria* from strata of Tertiary age in California are referable to the subgenus *Cardiomya*. Ten species have been reported living in the eastern Pacific between the Bering Sea and Ecuador. Six species of this subgenus have been reported from Japanese waters.

Cuspidaria (Cardiomya) pectinata Carpenter Plate 57, Figure 14

Neaera pectinata Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 602, 637, issued August, 1864. Reprint in Smithsonian Misc. Coll., No. 252, pp. 88, 123, 1872. — Carpenter, Proc. Acad. Nat. Sci. Philadelphia, Vol. 17, p. 54, 1865. "Hab. - In sinu Pugetiano junior legit Kennerley." "Apud insulam catalinam et Sanct. Barbaram adultum piscavit Cooper." — Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 181, pl. 18, fig. 11, 1903. Lower San Pedro Series at Deadman Island, San Pedro, California, Pleistocene.

Cuspidaria pectinata Carpenter, I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 101, 1924 (under section *Cardiomya*). Type locality, Puget Sound. Range, Puget Sound to Panama Bay.

Cuspidaria (Cardiomya) pectinata Carpenter, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 265, pl. 1, figs. 16, 17, 1931. Pleistocene and Recent. — Hertlein and Strong, Zoologica, Vol. 31, Pt. 3, p. 101, 1946. Cedros Island, Lower California. — K. V. W. Palmer, Geol. Soc. Amer., Mem. 76, p. 78, pl. 6, figs. 1-5, 1958. Earlier records cited. — Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 234, fig. 600, 1958. Puget Sound to Cedros Island, Lower California.

Type specimen. — No. 4506, United States National Museum.

Type locality. — "Puget Sound Washington (type)" (see Palmer, 1958, p. 79).

Range. — Middle Pliocene to Recent. Recent from Puget Sound to Cedros Island, Lower California, in 18 to 82 meters (10 to 45 fathoms). Reported from west of Mazatlan, Sinaloa, Mexico, in 84 to 92 meters (Parker, R. H., Vidensk. Medd. Dansk. Naturh. Foren., Bd. 126, p. 162, 1964).

Occurrence in San Diego Fm. — L.A.M. Loc. 305A.

Original description. — "Principal ribs about 12; beak smooth. Like *sulcata*. 40-60 fm. cp." (Carpenter, 1864.)

Supplementary description. — N. t. globosâ, albidâ, subdiaphanâ; epidermide tenui indutâ; ventraliter antice productâ, postice subito angustato, rostrato; rostro haud inculpto, duabus inter quinque partes toius longitudinis aequante; parte globosâ acute costatâ; costis posticis paulum majoribus, magis distantibus; margines dorsales versus obsoletis; interstitiis latis, quadratis, minutissime concentricè striatis; costis principalibus t. jun. xii, -xv., adultâ, aliis crebre intercalantibus, circ. xxx., quarum primi majores: intus, laminâ cartilagineâ curtâ, sub umbones celata; dente postico satis elongato, regione adductoris intus clavulato; cicatricibus adductoribus subrotundatis, deorsum

sis; sinu palii parvo, lato: margine à costis pectinato. Long. .24, lat. .14, alt. .12. (Carpenter, 1865.)

Remarks. — One right valve 7 mm long and 4.2 mm high, is present in the collection of the Los Angeles County Museum from near the Mexican boundary. The valve is quite convex and the main portion is sculptured with about 14 radial ribs which reach the ventral margin. Some of these ribs develop by dichotomy of the major ribs and some as intercalaries.

The convexity and number of ribs agrees with that of Recent specimens of *Cuspidaria (Cardiomya) pectinata* from California. Specimens of this species from Puget Sound are twice as large as those from California but otherwise appear identical.

Cuspidaria (Cardiomya) californica Dall (1374) was described as possessing a smaller, proportionally longer and less inflated shell sculptured with 16 to 20 radial ribs, with a straighter rostrum ornamented with two strong radiating lirae. There is variation in a series of specimens of *C. pectinata* and as mentioned by Palmer, Carpenter called attention to the variability in the number of ribs. The relationship of the two species is now known with certainty.

The shell of *Cuspidaria (Cardiomya) oldroydi* Dall (1375), described from Puget Sound, was said to be larger and more inflated than that of *C. pectinata* but otherwise the two appear to be very similar.

Vedder (1376) recently reported "*Cardiomya cf. C. pectinata* (Carpenter)" from sandstone strata of Pliocene age northeast of Newport Beach, California.

Simonova (1377) reported a fossil under the name of *Cuspidaria (Cardiomya) pectinata* Carpenter from strata of late Tertiary age in the southeastern part of Sakhalin Island, but the illustration is not convincing as to the identity.

FAMILY VERTICORDIIDAE STOLICZKA

Shell equivalve, or nearly so, of small size, inflated, with the beaks incurved, closed all around, more or less solid, pearly inside; hinge with few cardinal teeth, more or less obsolete, ligament subinternal or internal; two muscular impressions, pallial line simple. (Tryon, G. W., Jr., Struct. and Syst. Conch., Vol. 3, p. 196, 1884.). Paleocene to Recent.

Remarks. — Members of this family are widely distributed geographically and geologically. They occur as early as Paleocene in some regions but the present record of *Verticordia* in the San Diego Formation is the earliest known in western North America.

Kuroda (1378) discussed the Verticordiidae of Japan and Iredale (1379) proposed a number of genera for species of this family living in Australian waters. Soot-Ryen (1380) recently discussed this family, especially northern members of the group.

GENUS VERTICORDIA WOOD

Verticordia J. E. Gray, Synop. Contents Brit. Mus., ed. 42, p. 150, 1840. (*Nomen nudum*. See Iredale, T., Proc. Malacol. Soc. London, Vol. 10, pp. 299, 309, 1913.)
Verticordia S. Wood in Sowerby, Min. Conch. Great

Britain, Vol. 7, p. 67, pl. 639, August 1, 1844. Sole species, *Verticordia cardiiformis* J. Sowerby. — S. Wood, Palaeontogr. Soc. (London), Vol. 24, Eocene Moll., Vol. 1, Pt. 4, No. 3, p. 137, 1871. — Dall, Bull. Mus. Comp. Zool., Vol. 12, No. 6, p. 285, 1886. "The type of *Verticordia* as restricted is *V. cardiiformis* Sowerby (Min. Conch., pl. 639, 1844)." — Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 6, p. 1509, 1903. "Type *Cryptodon verticordia* Searles Wood, + *Hippagus cardiiformis* Sowerby." — Prashad, Siboga Exped. Monogr. 53c, Lamell., p. 323, 1932. "The Genotype is *Verticordia cardiiformis* Sowerby." — Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 68, 1953. "Type by monotypy: *Verticordia cardiiformis* Sowerby." — Stenzel, Krause, and Twining, Univ. Texas, Bull. Bur. Econ. Geol., Publ. No. 5704, p. 177, 1957. Type by monotypy.

Type species (by monotypy). — *Verticordia cardiiformis* J. Sowerby (on pl. 639, figs. a, b, c, d) cited as "*Hippagus ? cardiiformis*" on p. 68 (in the synonymy of which is "*Cryptodon Verticordia*, S. V. Wood, Cata. Ann. and Mag. Nat. Hist. v, vi. 247"). "coralline crag of Sutton." [Pliocene.] Illustrated by S. V. Wood, Palaeontogr. Soc. (London), Vol. 4, Monogr. Crag Moll., Pt. 2, p. 150, pl. 12 figs. 18a, 18b, 1850 issued June, 1851 (as *Hippagus verticordius*). "Coralline Crag, Sutton." — Tryon, Struct. and Syst. Conch., Vol. 3, p. 197, pl. 125, fig. 26, 1884.]

Range. — Paleocene (1381) to Recent. Widely distributed over the world. Recent in from 9 to 4261 meters (5 to 2330 fathoms).

Description. — Shell generally small, suborbicular, cardiform, equivalve, the beaks strongly prosogyrate above a deep, entering lunular indentation with thickened margins. Shell texture heavy, nacreous within and with a thin, chalky outer layer minutely shagreened. The hinge of the right valve shows a stout, conical cardinal tooth placed behind the lunular indentation; there are no laterals. Ligament internal, supported by a lithodesma. Pallial line simple. Sculpture is formed by strong, radial ribs. [Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 469, 1961.]]

Remarks. — Fischer (1382) discussed the generic units *Verticordia* and *Hippagus* and the species assigned to them.

The genus *Verticordia* is here reported from the San Diego Formation for the first time.

Two species in west American waters have been assigned to *Verticordia s. s.* These are *V. aequicostata* Howard (1383) and *V. perplicata* Dall (1384). One species living in this region is placed in the subgenus *Trigonulina*.

SUBGENUS TRIGONULINA D'ORBIGNY

Trigonulina d'Orbigny in Sagra, Hist. Phys. Pol. et Nat. Cuba, Vol. 7, Moll., Vol. 2, p. 291, 1846. Sole species, *Trigonulina ornata* d'Orbigny. — Dall, Bull. Mus. Comp. Zool., Vol. 12, No. 6, p. 286, 1886. Type by monotypy. — Woodring, Carnegie Inst. Washington, Publ. 366, p. 92, 1925. Type by monotypy. — Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 68, 1953. Type by monotypy.

Type species (by monotypy). — *Trigonulina ornata* d'Orbigny.

Range. — Eocene to Recent.

Description. — Shell similar to *Verticordia*, but the ribs more irregularly and widely spaced on posterior side. Right valve with a long, posterior lateral socket. (Olsson and Harbison.)

Remarks. — Only one species, the type of this subgenus, has been reported both as a fossil and Recent from the western Americas but a number of species occur in other regions.

Verticordia (Trigonulina) ornata d'Orbigny

Plate 43, Figures 23, 26, 27, 31

Trigonulina ornata d'Orbigny in Sagra, Hist. Phys. Polit. et Nat. Cuba, Vol. 7, Moll., Vol. 2, p. 292, pl. 27, figs. 30, 31, 32, 1853. — Chenu, Man. de Conchyl., Vol. 2, p. 169, fig. 843, 1862.

Verlicordia ornata d'Orbigny, Dall, Bull. Mus. Comp. Zool., Vol. 9, No. 2, p. 105, 1881. "Barbados, 100 fms." "Station 19, 310 fms." "Catalina Island, California, 16 fms. Dall; shell sand, Jamaica, W. I., d'Orbigny." [Not the record "China Seas, Adams."] — I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 103, pl. 54, figs. 15, 16, 17, 18, 1924. "Catalina Island, California, to Panama Bay" and "Antilles." [Not the record "Japan."] — Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 266, pl. 13, fig. 4, 1931. Pleistocene and Recent. — McLean, New York Acad. Sci., Surv. Porto Rico and Virgin Islands, Vol. 17, Pt. 1, p. 51, pl. 10, fig. 5, April 11, 1951. "Porto Rico: Mayaguez," Recent.

Verticordia (Trigonulina) ornata d'Orbigny, Dall, Bull. Mus. Comp. Zool., Vol. 12, No. 6, p. 290, 1886. Same localities cited as in 1881. — Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New

York), p. 469, 1961. California to Panama; Caribbean, West Indies to Massachusetts.

Verticordia novemcostata Adams and Reeve, Arnold, Mem. Calif. Acad. Sci., Vol. 3, p. 126, pl. 17, fig. 10, 1903. "Pleistocene. — San Pedro (Arnold)". Also Recent. Not *Hippagus novemcostatus*, Adams and Reeve, Voy. Samarang, Moll., p. 76, pl. 24, fig. 1, 1850. "Hab. China Sea."

Type specimen. — British Museum (Natural History.)

Type locality. — "Nous l'avons découverte dans le sable de la Jamaïque."

Range. — Middle Pliocene to Recent. Recent, Monterey Bay, California, to Panama Bay, in 37 to 160 meters (20 to 88 fathoms). Caribbean region, North Carolina to the West Indies, in 15 to 1256 meters (8 to 687 fathoms).

Occurrence in San Diego Fm. — L.A.M. Loc. 305.

Original description. — Testa rotundato-ovato, compressa, sordide albida, radiatim 9 costata; costis erectis, elevatis; latere buccali 6 approximatis; anli externè unicostato, in medio 2 approximatis; interstitiis striatis. (d'Orbigny.)

Remarks. — Several valves of this small, rounded, pearly shell were collected by G. P. Kanakoff near the Mexican boundary. The largest specimen is about 4 mm long.

The shape and the presence of eight or nine ribs, chiefly on the anterior two thirds of the valves, easily serve to separate this from other species in the faunal assemblage at San Diego. This is the first record of this species from beds of undoubted Pliocene age in western North America.

Most workers have been unable to detect any constant difference between shells referred to *Verticordia ornata* from east and west American waters. The east American species of this group were discussed by Dall in 1886.

Early records of *V. novemcostata* Adams and Reeve from western North America are now referred to *V. ornata*. The species described by Adams and Reeve is believed to be restricted to Oriental waters.

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- (252) See Fleming, C. A., "The genus *Pecten* in the Pacific," Jour. de Conchyl., Vol. 90, No. 4, pp. 276-282, pl. 1, January 25, 1951, also "The genus *Pecten* in New Zealand," New Zealand Geol. Surv., Paleo. Bull. 26, pp. 1-69, pls. 1-15, 1957.
- (253) Druckerman, D., "The genus *Pecten* in the new world." A thesis submitted in partial satisfaction of the requirements for the degree of Master of Science in Paleontology in the Graduate Division of the University of California, June, 1961. Pp. I-IV, 1-119, pls. 1-14, tables 1-3. See especially p. 25.

- (254) See *Pecten (Pecten) bellus* variety *hemphilli* Dall, Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 60, pl. 7, figs. 3, 5, 1950. From Loc. 795 (CAS), Punta Santa Antonita, Lower California, middle Pliocene.
- (255) See preceding reference, p. 66, pl. 12, fig. 2; pl. 13, fig. 4.
- (256) See Vokes, H. E., in Wilson, I. F., Bull. Amer. Assoc. Petrol. Geol., Vol. 32, No. 9, p. 1783, 1948, also Univ. Nac. Auton. de Mexico, Inst. Geol. y Geofis. y Geodesia, Bol. No. 53, p. 39, 1948.
- (257) *Pecten (Pecten) auburyi* Arnold, U.S.G.S., Prof. Paper 47, p. 94, pl. 33, figs. 2, 2a; pl. 34, figs. 2, 2a, 1906. "Pliocene. Locality 38, 1 mile east of the Chandler wells, Puente Hills; Los Angeles County (Watts)." Also from other localities.
- (258) *Pecten (Pecten) lecontei* Arnold, U.S.G.S., Prof. Paper 47, p. 98, pl. 33, figs. 4, 4a, 4b, 1906. "Pliocene, Cerros Island, Lower California (University of California)."
- (259) *Pecten (Pecten) slevini* Dall and Ochsner, Proc. Calif. Acad. Sci., Ser. 4, Vol. 17, No. 4, p. 118, pl. 3, fig. 9; pl. 4, fig. 4, June 22, 1928. "from upper horizon (zone D), on east shore of Indefatigable Island, Galapagos Group. Probably Pliocene."
- (260) See *Pecten (Janira) bellus* (Conrad) variety *slevini* Dall and Ochsner, Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 227, pl. 2, fig. 3, 1931. "from locality 258, middle Pliocene (oyster-bed facies) north of the Santa Clara Valley and east of San Martinez Chiquito Canyon, Los Angeles Co."
- (261) See *Pecten (Pecten) archon* Maury, Bull. Amer. Paleo., Vol. 10, No. 42, p. 236 (84), pl. 27 (16), figs. 2, 3, 5, March 27, 1925. "Springvale." "Upper Miocene," Trinidad.
- (262) See *Pallium albicans* Schröter, Archiv f. Zool. u. Zootomie, Bd. 3, p. 136, 1802. Illustrated by Kira, "Shells of the Western Pacific in Color" (Hoikusha Publ. Co.: Osaka, Japan), p. 134, pl. 48, fig. 3, 1962. Southern Hokkaido to Kyūshū, Japan. [This is an earlier name for *Pecten laqueatus* Sowerby, Thes. Conch., Vol. 1, p. 46, pl. 15, fig. 101, 1842. "Brought by Capt. Dixon from N. W. America." See Rehder, H. A., Nautilus, Vol. 58, No. 2, p. 54, 1954.]
- (263) *Pecten excavatus* Anton, Verzeichniss der Conchylien (Eduard Anton: Halle), p. 19, 1839. "Vaterland China." Illustrated by Kira, "Shells of the Western Pacific in Color" (Hoikusha Publ. Co.: Osaka, Japan), p. 134, pl. 48, fig. 2, 1962. "Southern part of Japan, Formosa and southern China, in shallow waters."
- (264) See Fleming, C. A., Trans. Roy. Soc. New Zealand, Vol. 79, p. 128, 1951.
- (265) Báldi, T. (Ann. Hist.-Nat. Mus. Nat. Hungarici, Vol. 58, pp. 71, 82, 1966), cited *Flabellipeecten* from strata which he believed to be of late Oligocene age.
- (266) See Toulou, F., Jahrb. d. K. K. Geol. Reichsanstalt, Bd. 58, Heft 4, explanation of pl. XXVI (II), fig. 2, 1908.
- (267) *Pecten (Pecten) hawleyi* Hertlein, Bull. South. Calif. Acad. Sci., Vol. 24, May-August, Pt. 2, p. 40, pl. 4, figs. 4, 5, August 17, 1925. "upper beds of the Vaqueros sandstones, Santa Inez Mountains, Santa Barbara County, California."
- (268) These authors include some species in *Flabellipeecten* which are referable to *Amussiopecten* which we consider to be a separate subgenus.
- (269) *Pecten (Pecten) diegensis* Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 710, April, 1898. "Pleistocene of San Diego; Hemphill. Living on the adjacent shores from Monterey, California, southward." A new name for *Pecten floridus* Hinds (Zool. Voy. Sulphur, Moll., Pt. 3, p. 60, pl. 17, fig. 6, 1844, January, 1845). "Inhab. San Diego, California. In five fathoms, among mud." [Not *Ostrea florida* Gmelin, 1791, a *Pecten*.]—Grau, Allan Hancock Pac. Exped., Vol. 23, p. 143, pls. 52, 53, 1959.
- (270) *Pecten lunaris* S.S. Berry, Leaflets in Malacol., Vol. 1, No. 23, p. 139, September 30, 1963. "Type-Locality: 30-45 fms., off Morro Colorado, Sonora; Capt. Antonio Luna, Mar. 1963."
- (271) *Pecten sericeus* Hinds, Zool. Voy. Sulphur, Moll., Pt. 3, p. 60, pl. 17, figs. 1, 1a, 1844 (January, 1845, on cover of Pt. 3). "Inhab. Bay of Panama. In fifty-three fathoms, on a muddy floor."—Grau, Allan Hancock Pac. Exped., Vol. 23, p. 141, pls. 50, 51, 1959.
- (272) *Pecten (Pecten) carrizoensis* Arnold, U.S.G.S., Prof. Paper 47, p. 59, pl. 4, figs. 1, 1a, 1b, 2, 3, and 3a, 1906. From "the head of Garnet Canyon, about 12 miles north of the Mexican boundary, in the Carrizo Creek district, San Diego County." Miocene. [Pliocene.] [On page 152 the type is cited as from Alverson Canyon.]
- (273) *Pecten (Pecten) beali* Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 1, p. 10, pl. 2, fig. 3; pl. 5, fig. 8, July 21, 1925. "pebbly sandstone near Comondú-Salada contact, Arroyo near La Palma, Lower California." "Salada, Pliocene."
- (274) *Pecten ochlockoneensis violae* Tucker, Amer. Midland Nat., Vol. 17, No. 2, p. 481, pl. 1, figs. 1, 2, March, 1936. "Jackson Bluff, Fla. (type)." "Choctawhatchee (Miocene)."
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- (276) See Vokes, H.E., in Wilson, I.F., Bull. Amer. Assoc. Petrol. Geol., Vol. 32, No. 9, p. 1782, 1948.
- (277) *Pecten soror* Gabb, Pilsbry, Proc. Acad. Nat. Sci. Philadelphia, Vol. 73, Pt. 2, p. 410, pl. 44, figs. 1, 2, 1921, issued January 30, 1922.
- (278) *Pecten soror codercola* Harris, Bull. Amer. Paleo., Vol. 13, Bull. 49, p. 23, pl. 13, fig. 3; pl. 14, figs. 1, 5; pl. 15, fig. 7, October 7, 1927. "Districts of Democracia and Colina, State of Falcón, locality numbers 69, 123." Venezuela. "Miocene and Pliocene."
- (279) See Fitch, J.E., State Calif. Dept. Fish Game, Mar. Fish. Branch, Fish Bull. No. 90, p. 43, fig. 9, 1953.
- (280) See Fleming, C. A., "The genus *Pecten* in New Zealand." New Zealand Geol. Surv., Paleo. Bull. 26, pp. 1-69, pls. 1-15, 1957.
- (281) *Pecten (Pecten) heimi* Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 1, p. 9, pl. 1, fig. 3; pl. 3, fig. 3, July 21, 1925. "southern part of Arroyo San Gregorio, Lower California: . . . Lower Pliocene?"
- (282) *Pecten (Pecten) juanensis* Grant and Stephenson, Jour. Paleo., Vol. 22, No. 6, p. 804, pl. 124, figs. 1-4, November, 1948. "UCLA Locality 435, sandstone fossil reef on east side of valley of San Juan Creek, at elevation of about 1500 feet above sea level, in west middle half of section 32, Township 28 south, Range 16 East (Mount Diablo Base and Meridian), eastern San Luis Obispo County, California. Stratigraphic position: approximately at conformable contact between lower and upper Neroly, lower half of the upper third of the Miocene."
- (283) *Pecten coalingaensis* Arnold in Anderson, Proc. Calif. Acad. Sci., Ser. 3, Geology, Vol. 2, No. 2, p. 197, pl. 18, figs. 94-98, December 4, 1905. "This species is common in the Etchegoin Beds of the Mount Diablo Range, at the Kreyenhagen ranch on Zapata Chino Creek." "probably Pliocene."—Arnold, U.S.G.S., Prof. Paper 47, p. 97, pl. 4, figs. 4, 4a, 5, 1906 (as *Pecten (Pecten) coalingaensis*).
- (284) *Pecten (Oppenheimopekten) hancocki* Grau, Allan Hancock Pac. Exped., Vol. 23, p. 154, pl. 57, September 25, 1959. "Chatham Bay, Cocos Island, Costa Rica, in 47 fathoms, coarse white sand."
- (285) See *Pecten aduncus* Eichwald, Depéret and Roman, Mém. Soc. Géol. France, Paléo., Tome 10, Fasc. 1, Mém. No. 26, p. 49, pl. 6, figs. 6, 6a, 1902.
- (286) *Pecten (Pecten) perulus* Olsson, Mollusks of the tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 158, pl. 20, figs. 3, 3a-c; pl. 21, figs. 3, 3a, March 10, 1961. "Santa Elena, Ecuador. Holotype, ANSP 218918."
- (287) See Hoffstetter, R., Bol. Inform. Cienc. Nat. (Quito), Vol. 2, Nos. 13, 14, p. 73, 1948.
- (288) See *Patinopeecten* sp., Schenck, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 1, p. 28, 1928. Yaquina sandstone,

western Oregon.

(289) Akiyama, M., "Studies on the phylogeny of *Patinopecten* in Japan," Sci. Repts. Tokyo Kyoiku Daigaku, Geol. Min. Geogr., Sec. C, Vol. 8, No. 74, pp. 63-122, pls. 1-8, figs. 1-3, in text, February 5, 1962.

(290) *Masudapeecten* Akiyama, 1962, p. 107. "Type species. *Patinopecten masudai* Akiyama, sp. nov., p. 107, pl. 1, fig. 2; pl. 3, fig. 1, February 5, 1962 (as *Patinopecten (Masudapeecten) masudai* Akiyama). From the Sugota Formation, Akita Prefecture, early Miocene.

(291) Masuda, K., "The so-called *Patinopecten* of Japan," Trans. Proc. Palaeo. Soc. Japan, New Ser., No. 52, pp. 145-153, pls. 22, 23, December 10, 1963.

(292) *Blanckenhornia* von Teppner, Foss. Cat. 1: Anim., Edit. a C. Diener, Pars 15, Lamell. Tert., Anisomyaria II, p. 260, 1922. "Typus: *Pecten (Blanckenhornia) oweni* Arnold."

(293) See Jaworski, E., Palaeo. Zeitschr., Bd. 1, Heft 2, p. 296, 1914.

(294) *Fortipecten* Yabe and Hatai, Sci. Rept. Tohoku Imper. Univ., Sendai, Japan, Ser. 2 (Geol.), Vol. 21, no. 2, p. 149, 1940. "Type: pl. XXXIV (1), Figs. 4-6." [= *Pecten takahashii* Yokoyama, 1930.]

(295) *Pecten (Patinopecten) lohri* Hertlein, Nautilus, Vol. 41, No. 3, p. 93, January, 1928. New name for *Pecten (Patinopecten) oweni* Arnold, U.S.G.S., Prof. Paper 47, p. 63, pl. 8, figs. 1, 1a, 1b, 1906. "Foxin's ranch, Santa Barbara County, Cal." Pliocene. (Not *Pecten oweni* DeGregorio, 1884.)—Hanna and Hertlein, Calif. State Div. Mines, Bull. 118, p. 176, fig. 65-1 (p. 177), 1941. Beds at railroad bridge across Waltham Creek, about 2 miles southwest of Coalinga, Fresno Co., California. Jacalitos formation, lower Pliocene.

(296) The specimen from that region illustrated by the senior author under the name of *Pecten lohri* can be referred to *P. healeyi*. See Calif. State Div. Mines, Bull. 154, p. 189, fig. 2, (on p. 188), 1951.

(297) *Pecten propatulus* Conrad, U.S. Explor. Exped. (Wilkes), Vol. 10, Geol., ap. p. 726, atlas, pl. 18, figs. 13, 13a, 1849. "Astoria, Oregon." Miocene.—Arnold, U.S.G.S., Prof. Paper 47, p. 64, pl. 7, fig. 1; pl. 9, figs. 1, 1a, 2, 2a, 1906 (as *Pecten (Patinopecten) propatulus*). —Moore, U.S.G.S., Prof. Paper 419, p. 64, pl. 16, figs. 1-4; pl. 17, figs. 2-5, 7, 1963 (as *Patinopecten propatulus*). (Lectotype.)

(298) *Pecten (Patinopecten) haywardensis* Lutz, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 28, No. 13, p. 386, pl. 17, figs. 9, 10, October 16, 1951. Hayward quadrangle, California; Sobrante Sandstone, middle Miocene.

(299) *Pecten (Patinopecten) haywardensis calaverasensis* Hall, Univ. Calif. Publ. Geol. Sci., Vol. 34, No. 1, p. 51, pl. 2, fig. 2; pl. 3, fig. 4; pl. 4, fig. 3, November 24, 1958. "Middle Miocene, Oursan sandstone."

(300) *Pecten oregonensis* Howe, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 14, No. 3, p. 98, pl. 11, figs. 1, 2; pl. 12, figs. 1, 2, September 8, 1922. Type locality: West side of Coos Head, mouth of Coos Bay, Oregon. Pliocene. A subspecies, *Patinopecten oregonensis cancellus* Moore (1963, p. 65, pl. 17, figs. 6, 8, 9; pl. 18, figs. 1, 4) was described from "Dredgings from the Miocene rocks, Coos Bay, Oreg."

(301) *Pecten tryblum* Yokoyama, Jour. Fac. Sci. Imper. Univ. Tokyo, Sec. II, Geol., Vol. 1, Pt. 1, p. 17, pl. 6, figs. 1, 2; pl. 7, figs. 1, 5, August 29, 1925. "Shigarami and Sakae." Japan.

(302) *Pecten yamasakii* Yokoyama, Jour. Fac. Sci. Imper. Univ. Tokyo, Sec. II, Geol., Vol. 1, Pt. 1, p. 17, pl. 5, figs. 1, 2, 4, 5, August 29, 1925. "Shigarami and Togakushi." Japan.—Akiyama, Sci. Repts. Tokyo Kyoiku Daigaku, Geol. Min. Geogr., Sec. C, Vol. 8, No. 74, p. 95, pl. 3, fig. 3; pl. 6, fig. 3, 1962 (as *Patinopecten (Patinopecten) yamasakii yamasakii*). Early Pliocene of Japan.

(303) Kuroda, T., Fossil Moll. (in F. Homma), Shinano Chûbu Chishitsu-Shi (Geol. Central Shinano), Pt. 4, p. 35, pl. 2, figs. 7, 8, 1931.

(304) *Patinopecten yamasakii ninohensis* Masuda, Saito Ho-On Kai Mus. Res. Bull., No. 23, (Geol., No. 2), p. 13, figs. 1-3, September, 1954. Lowermost Suenomatsuyama Formation in the Iwate Prefecture, Japan; late Miocene.

(305) *Pecten (Patinopecten) duplex* Cooks, Carnegie Inst. Washington, Publ. 291, p. 140, pl. 11, figs. 10a, 10b, 1919. "Long Island, Antigua, station 6869, Vaughan." "Oligocene." —Olsson and Richards, Notulae Naturae Acad. Nat. Sci. Philadelphia, No. 350, p. 5, pl. 1, figs. 5, 6, 1961 (as *Pecten (Flabellipecten) duplex*). Goajira Peninsula of Colombia. "Probably Upper Oligocene."

(306) *Pecten (Patinopecten) yakatagensis* Clark, Bull. Geol. Soc. Amer., Vol. 43, No. 3, p. 807, pl. 16, fig. 1, September 30, 1932. Yakataga Reef, southeastern Alaska.

(307) *Pecten oregonensis* Howe var., Manning and Ogle, Calif. State Div. Mines, Bull. 148, pl. 6, 1950.

(308) See *Patinopecten (Lituyapecten) falorensis* MacNeil, U.S.G.S., Prof. Paper 354-J, p. 234, pl. 38, figs. 1 and 3, 1961. Falor Formation, Pliocene.

(309) Ogle, B.A., "Geology of Eel River Valley Area Humboldt County, California," Calif. State Div. Mines, Bull. 164, pp. 44-45, 1953.

(310) *Patinopecten (Lituyapecten) poulcreekensis* MacNeil, U.S.G.S., Prof. Paper 354-J, p. 228, pl. 35, figs. 1-6; pl. 36, figs. 1, 2(?), 3, 4, 6, 7; pl. 38, fig. 2, 1961. Type locality, "Uppermost part of the Poul Creek formation at Yakataga Reef, USGS loc. M-271." Early Miocene.

(311) See *Patinopecten (Patinopecten) poculum kurosawaensis* Yokoyama, Akiyama, Sci. Repts. Tokyo Kyoiku Daigaku, Geol., Min. Geogr., Sec. C, Vol. 8, No. 74, p. 101, pl. 4, fig. 3, 1962. See also remarks on pp. 112, 115.

(312) *Pecten (Patinopecten) purissimaensis* Arnold, U.S.G.S., Prof. Paper 47, p. 105, pl. 34, fig. 3; pl. 35, figs. 1, 1a, 1906. "Purissima formation (lower Pliocene), north of the mouth of Pescadero Creek, San Mateo County, Cal." —MacNeil, U.S.G.S., Prof. Paper 354-J, p. 233, pl. 44, figs. 1, 3, 1961 [as *Pecten (Lituyapecten) purissimaensis*].

(313) Arnold, R., and Hannibal, H., "The Marine Tertiary Stratigraphy of the North Pacific Coast of America," Proc. Amer. Philos. Soc. Vol. 52, No. 212, p. 594, 1913.

(314) *Pecten coosensis* Shumard, Trans. St. Louis Acad. Sci., Vol. 1, Pt. 2, p. 122, 1858. "found in great profusion at the mouth of Coos Bay, in slightly coherent sandstone of the Miocene period." —Weaver, Univ. Washington Publ. Geol., Vol. 5, p. 92, pl. 18, figs. 1, 2; pl. 21, figs. 2, 5, 1942 (issued December 31, 1943) (as *Pecten (Patinopecten) coosensis*). —Trumbull, Jour. Paleo., Vol. 32, No. 5, p. 901, pl. 115, figs. 1-4; pl. 116, figs. 1, 2; pl. 117, fig. 4, 1958 (as *Patinopecten coosensis*). [Specimens from type lot illustrated.]

(315) *Patinopecten (Patinopecten) nakatombetsuensis* Akiyama, Sci. Repts. Tokyo Kyoiku Daigaku, Sec. C, Geol. Min. Geogr., Vol. 8, No. 74, p. 100, pl. 4, figs. 2, 5, February 5, 1962. Nakatombetsu Formation, early Pliocene.

(316) See Gillet, S., Mém. Soc. Géol. France, New Sér., Tom. 1, Fasc. 3 and 4, Mém. No. 3, p. 46, 1924.

(317) See Fedotov, D. M., "Über die Variabilität der rezenten Peleceypoden im Zusammenhang mit der Untersuchung fossiler Formen," Trav. Inst. Paléozool. Acad. Sci., URSS, (Leningrad), Tome 2, pp. 1-16, pls. 1-3, 1933.

(318) Staesche, K., "Die Pectiniden des Schwabischen Jura," Geol. u. Palaeo. Abhandl., Neue Folge, Bd. 15 (Whole Ser. Bd. 19), Heft 1, pp. 1-136, pls. 1-6, figs. 1-12 in text, 1926.

(319) Dechaseaux, C., "Pectinidés Jurassiques de l'est du Bassin de Paris," Ann. Paléo., Tom. 25, Fasc. 1-3, pp. 1-148, pls. 1-10, March, 1936.

(320) *Pecten (Chlamys) lawsoni* Arnold, U. S. G. S., Prof. Paper 47, p. 117, pl. 45, figs. 3, 4, 1906.

(321) See Adegoke, O. S., Univ. Calif. Publ. Geol. Sci., Vol. 80, p. 97, 1969.

(322) *Pecten (Chlamys) hastatus* Sowerby, var. *ingeniosa* Yo-

- koyama, Imper. Geol. Surv. Japan, Rept. 104, p. 5, pl. 6, fig. 2, 1929. "near Nanao."—Masuda, Sci. Repts. Tohoku Univ., Sendai, Japan, Second Ser. (Geol.), Vol. 33, No. 2, p. 170, pl. 22, fig. 13, 1962 (as *Chlamys ingensiosa*).
- (323) *Pecten (Pecten) hastatus* Sow. var. (?), Slodkewitsch, Trans. Geol. Oil Inst., Ser. A, Fasc. 79, p. 153, pl. 12, fig. 3, 1936.
- (324) See Lamy, E., Bull. Mus. Nat. Hist. Nat. (Paris), Vol. 34, No. 2, p. 170, 1928.
- (325) *Pecten denticulatus* Adams and Reeve, in A. Adams, Zool. Voy. Samarang, Moll., p. 74, pl. 21, fig. 14, 1850.
- (326) See Bavay, E., Jour. de Conchyl., Vol. 79, No. 4, p. 309, 1936.
- (327) See *Chlamys odontata* Cox, Proc. Malacol. Soc. London, Vol. 18, Pt. 5, p. 205, July 15, 1929.
- (328) According to A. M. Keen (Veliger, Vol. 2, No. 4, p. 101, April, 1960), *hericius* "is a noun, not an adjective, derived from the latin word *ericius*, hedgehog."
- (329) *Pecten (Chlamys) miyatokoensis* Nomura and Hatai, Saito Ho-On Kai Mus., Res. Bull., No. 13, p. 127, pl. 19, figs. 2-4; pl. 20, fig. 1, August, 1937. "Otutumi" and "Sabusawa," Japan, Miocene.—Masuda, Trans. Proc. Palaeo. Soc. Japan, New Ser., No. 24, p. 247-250, pl. 35, figs. 1-9b, 1956 (as *Chlamys miyatokoensis*).
- (330) See Masuda, K., Trans. Proc. Palaeo. Soc. Japan, New Ser., No. 22, p. 176, pl. 29, figs. 1-7, 1956. (See remarks p. 179).
- (331) *Pecten kaneharai* Yokoyama, Jour. Fac. Sci. Imper. Univ. Tokyo, Sec. 2, Vol. 1, Pt. 4, p. 135, pl. 8, fig. 1; pl. 19, figs. 1,2,5-7, January 9, 1926. Shiobara in Shimotsuké, Japan, Pliocene. See also, Makiyama, J., Palaeo. Soc. Japan, Spec. Papers No. 4, pl. 36, fig. 1; pl. 37, figs. 1, 2, 5, 6, 7, 1958.
- (332) See Philippi, E., Zeitschr. Deutsch. Geol. Gesell., Bd. 52, Heft 1, figs. 9 and 10, 1900.
- (333) *Pecten islandicus pugetensis* I. S. Oldroyd, Nautilus, Vol. 33, No. 4, p. 136, pl. 4, figs. 5 and 6, April, 1920. "off San Juan, Puget Sound."; Publ. Puget Sound Biol. Sta., Vol. 4, p. 136, pl. 4, figs. 5 and 6, 1924 (as *Pecten (Chlamys) islandicus pugetensis*); Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 55, pl. 2, figs. 4 and 5, 1924. See also MacNeil, U. S. G. S. Prof. Paper 553, p. 15, pl. 22, figs. 4, 5, 1967 (as *Chlamys ("Chlamys") pugetensis*). Sitkalidak Island, off Kodiak Island, Alaska.
- (334) Gregg, W. P., Nautilus, Vol. 51, No. 4, p. 118, April, 1938.
- (335) See Henderson, J., Univ. Colorado Studies, Vol. 16, No. 1, p. 2, June, 1927.
- (336) The altitude of the type specimen was given as 51 mm. in the explanation of plate 12, figure 6, in the original publication. This apparently was an error because Arnold in 1906 gave the altitude as 45 mm. and measurements of his illustration substantiate this figure.
- (337) See *Pecten (Pecten)* cf. *islandicus* var. *jordani* Arnold, Kundert, Calif. State Div. Mines, Spec. Rept. 18, p. 15, 1952. Whittier-LaHabra area, California, Pico Formation, Pliocene.
- (338) See *Chlamys islandicus jordani* Arnold, Woodring, U. S. G. S., Prof. Paper 207, p. 80, pl. 32, fig. 16, 1946. "Timms Point silt," San Pedro, California, Pleistocene.
- (339) See *Pecten (Chlamys) jordani* Arnold, I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 19, pl. 2, figs. 1, 2, 1924.—I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 55, pl. 28, figs. 5, 6, 1924.
- (340) *Pecten (Chlamys) hindsii kincaidi* I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 17, pl. 9, figs. 3, 4, 1924. "Off San Juan Island, Wash., in 25 fathoms.—Puget Sound."—I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 53, pl. 12, figs. 1, 2, 1924.
- (341) See *Chlamys rubida jordani* Arnold, Grau, Allan Hancock Pac. Exped., Vol. 23, p. 79, pl. 25, 1959.
- (342) See *Pecten (Chlamys) hindsii* var. *jordani* Arnold, Crickmay, Canadian Field Nat., Vol. 39, No. 6, p. 140, 1925. Road cut on Pacific highway on South side of Fraser River opposite New Westminster, British Columbia, Pleistocene; Vol. 43, No. 9, p. 206, 1929. Surrey, British Columbia, Pleistocene.
- (343) *Chlamys durhami* Adegoke, Univ. Calif. Publ. Geol. Sci., Vol. 80, p. 97, pl. 2, fig. 5, September 25, 1969.
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(430) *Stralopecten* Rowland, Jour. Conch., Vol. 21, No. 5, p. 81, September 22, 1938. Type (by original designation): *Stralopecten ernstsmithi* Tucker, illustrated in Mém. Mus. Roy. Hist. Nat. Belgique, Deuxième Sér., Fasc. 13, p. 27, pl. 2, fig. 7, 1938. Originally described in Proc. Indiana Acad. Sci., Vol. 40, pp. 244, 245, pl. 1, figs. 3, 4, 1931. North Carolina, Pliocene.

(431) *Pecten ethegoiini* F. M. Anderson, Proc. Calif. Acad. Sci., Ser. 3, Vol. 2, No. 2, p. 198, pl. 18, figs. 92, 93, December 4, 1905. "Etchegoin Beds of the Kreyenhagen ranch on Zapata Chino Creek."—Stewart, in Woodring, Stewart, and Richards, U.S.G.S., Prof. Paper 195, p. 91, pl. 13, fig. 5; pl. 32, fig. 1, 1940 (1941) (as *Chlamys ethegoiini*).

(432) *Pecten (Chlamys) hamlini* Arnold, U.S.G.S., Prof. Paper 47, p. 67, pl. 11, fig. 2, 1906. "Miocene (lower?), head of Slacks Canyon, Monterey County, Cal."

(433) *Pecten (Chlamys) nuttleri* Arnold, U.S.G.S., Prof. Paper 47, p. 67, pl. 11, figs. 3, 4, 4a, 1906. "Purisima formation (lower Pliocene), south of mouth of San Gregorio Creek, San Mateo County, Cal." (Type.)

(434) *Pecten (Chlamys) watsi* Arnold, U.S.G.S., Prof. Paper 47, p. 120, pl. 11, figs. 1, 1a, 1906. "The type is from Kreyenhagen's Ranch, Fresno County." [A lectotype, No. 5945, is in the series of type specimens in the department of Geology, California Academy of Sciences. See Hanna, G. D., and Hertlein, L. G., Calif. State Div. Mines, Bull. 118, Pt. 2, p. 176, pre-print August, 1941, made available September 11, 1941.]

(435) *Pecten (Chlamys) watsi* var. *morani* Arnold, U.S.G.S., Prof. Paper 47, p. 121, pl. 10, figs. 3, 4, 5, 6, 1906. "Pliocene (lower). T. H. Moran's place, SW. 1/4 sec. 14, T. 20S., R. 12 E., Mount Diablo Meridian, Priest Valley, Monterey County (Hamlin and Arnold)."

Reagan (Trans. Kansas Acad. Sci., Vol. 22, pp. 172, 198, 1909) reported the occurrence of "*Pecten (Chlamys) watsi* var. *morani* Arnold?" from beds exposed at East Clallam, western Washington. We have not seen specimens from that area.

(436) *Pecten (Chlamys) kindlei* Dall, U.S.G.S., Prof. Paper 125-C, p. 30, pl. 6, figs. 2, 7, 1920. "Pliocene of Center Creek Mines, 2 miles north of Nome, from the second beach." Alaska.—MacNeil, Jour. Paleol., Vol. 17, No. 1, p. 87, pl. 12, figs. 7, 8, 1943 (as *Pecten (Manupecten) kindlei*). Intermediate Beach, near Nome, Alaska, Pliocene. ?Second Beach, fragment.

(437) *Chlamys (Swiftopecten) doumilleri* MacNeil, U.S.G.S., Prof. Paper 553, p. 12, pl. 3, figs. 1, 4, 6, 1967. "Type locality: 1,500 ft above base of Yakataga Formation (horizon probably middle Miocene), south side of White River near foot of glacier, Yakataga district, Alaska, USGS 6694."

(438) See Arnold, R., U.S.G.S., Bull. 396, p. 77, 1909 (issued January 15, 1910.)

(439) See Nomland, J. O., Univ. Calif. Publ. Geol., Vol. 10, No. 14, p. 239, pl. 7, figs. 1-5; pl. 8, figs. 2, 2a, 2b, April 19, 1917.

(440) Clark, B. L., in Santillan, M., and Barrera, T., Ann. Inst. Geol., Vol. 5, p. 25, 1930. "en las terrazas al E. de San Quintín y entre Colnett y San Isidro." Pliocene.

(441) See Hertlein, L. G., and Allison, E. C., Bull. South. Calif. Acad. Sci., Vol. 58, Pt. 1, p. 21, 1959.

(442) *Pecten (Pallium) swiftii* Bernardi var. *etchehoiini* Anderson, Slodkewitsch, Paleol. USSR. Tertiary Pelecypoda from the Far East (Acad. Sci., USSR.) Vol. 10, Pt. 3, Fasc. 18, p. 179, 1938; also Fasc. 19, p. 109, pl. 28, figs. 1, 2, 2a, 3, 3a, 4, 5a; pl. 29, fig. 5, 1938.

(443) See Cummings, J. C., Touring, R. M., and Brabb, E. E., Calif. Div. Mines and Geol., Bull. 181, p. 200, photo 15, No. 2,

1962. Tahana member of the Purisima Formation, Pliocene.

(444) Smith, J. P., Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, p. 161, 1919.

(445) *Pecten (Lyropecten) hopkinsi* Olsson, Bull. Amer. Paleol., Vol. 19, Bull. No. 68, p. 83, pl. 5, figs. 1, 4, June 30, 1932. "Tumbez formation, Que. Tucillal at Zorritos." Peru, Miocene.

(446) Hass, O., Jour. Paleol., Vol. 16, No. 3, p. 309, May, 1942.

(447) See Dollfus, G. F., Jour. de Conchyl., Vol. 56, No. 1, pp. 64-66, August 25, 1908.

(448) Clark, B. L., and Durham, J. W., in Schenck, H. G., and Childs, T. S., Jr., Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 3, No. 2, pp. 61 (37)-62 (38), 1942.

(449) North, K. F., (pers. comm.).

(450) *Macrochlamis* Sacco, Bol. Mus. Zool. e Comp. Anat. (Torino), Vol. 12, No. 298, p. 101, June, 1897. "*Macrochlamis latissima* (Br.) (tipo del nuovo sottog.)." Sacco changed the spelling to *Macrochlamys* in Moll. Terr. Piemonte e Liguria, Pt. 24, p. 32, December, 1897. Not *Macrochlamys* Benson, 1832. According to the present rules of the Internatl. Comm. Zool. Nomencl., the earlier spelling by Sacco can be considered valid. Thus neither of the appropriate names *Gigantopecten* nor *Grandipecten* is available for this taxon.

(451) *Pecten antiquensis churuguarensis* F. and H. Hodson (Bull. Amer. Paleol., Vol. 13, No. 49, p. 35, pl. 20, figs. 1, 3, 4; pl. 22, fig. 2, October 7, 1927) described from beds said to be of "Oligocene" age in Venezuela, is a typical *Amussiopecten*. It bears a resemblance to some varieties of *Pecten burdigalensis* Lamarck, the type of *Amussiopecten*. See for example, *Amussiopecten burdigalensis* var. *spinosa* Sacco Moll. Terr. Terz. Liguria e Piemonte, Pt. 24, p. 53, pl. 15, fig. 9, December, 1897. "Vignale," Italy, Helvetian, Miocene.

(452) *Nodipecten* Dall, Trans. Wagner Free Inst. Sci., Vol. 3, Pt. 4, p. 695, April, 1898. "Type *P. nodosus* L."

(453) Roger, J., Mém. Soc. Géol. France, New Ser., Vol. 17, Fasc. 2-4, Feuilles 7-43, Mém. No. 40 (completion of Mém. de Paléo. No. 26), pp. 44, 46, 1939.

(454) See Eames, F. E., and Cox, L. R., Proc. Malacol. Soc. London, Vol. 32, Pts. 1 and 2, p. 59, 1956.

(455) See Grant, U. S., and Gale, H. R., Mem. San Diego Soc. Nat. Hist., Vol. 1, pl. 9, fig. 1; pl. 10, fig. 6, 1931.

(456) Live specimens of *Pecten subnodosus* were reported recently from off Santa Catalina Island, California, by Turner and Mitchell (Calif. Fish and Game, Vol. 54, No. 1, p. 53, fig. 3, January, 1968).

(457) *Athlopecten* Marwick, Trans. Proc. New Zealand Inst., Vol. 58, Pt. 4, pp. 447, 454, February 28, 1927. "Type: *Pecten athleta* Zittel" [Paläont. von Neu-Seeland, Novara Exped., Geol. Theil., Bd. 1, Abt. 2, p. 49, Taf. 10, fig. 1, 1864.] "Motupipi in der Massacre-Bay, Sudinsel."

(458) *Pecten simpsoni* Philippi, Los Fósiles Terciarios i Cuartarios de Chile (Santiago), p. 202, pl. 46, fig. 1, 1887. "Comun en Chiloé." Also "Hunñimo"; and "La Mocha, Navidad (raro), Curauma."

(459) See Boreham, A. U. E., "The New Zealand Tertiary genus *Seetipecten* Marwick (Mollusca)," Trans. Roy. Soc. New Zealand, Vol. 88, (quart. issue), Pt. 4, pp. 655-668, pls. 45-49, fig. 1 in text, February, 1961.

(460) Reported recently by Addicott (U.S.G.S., Prof. Paper 524-A, p. A-13, pl. 3, Fig. 8, 1965) from the Pancho Rico Formation, Salinas Valley, California, Pliocene.

(461) *Pallium estrellanum* Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 8, No. 6, p. 313, December, 1856 (apparently issued early in 1857) "Locality. Estrella valley, Cal. Dr. Newberry."—Arnold, U.S.G.S., Prof. Paper 47, p. 74, pl. 19, figs. 1, 1a; pl. 20, figs. 1, 2, 2a; pl. 21, figs. 1, 1a, 1b, 2, 2a, 2b, 1906 (as *Pecten (Lyropecten) estrellanus*). Late Miocene.

(462) *Pecten (Lyropecten) estrellanus* Conrad var. *terminus* Conrad, Arnold, U.S.G.S., Prof. Paper 47, p. 77, pl. 23, figs. 2, 2a,

1906. "Santa Margarita formation (upper Miocene), Monterey County, Cal." (expl. to plate). Woodring (U.S.G.S., Prof. Paper 190, p. 34, 1938) suggested that the specimen illustrated by Arnold on pl. 19, figs. 1, 1a, is probably referable to *P. e. terminus*.
- (463) *Pecten (Lyropecten) estrellanus* Conrad var. *catalinae* Arnold, U.S.G.S., Prof. Paper 47, p. 76, pl. 20, figs. 3, 3a, 4, 1906. "found in a limy matrix near Isthmus, Santa Catalina Island, Los Angeles County." "Upper Miocene."
- (464) *Pecten (Lyropecten) gallegosi* E. K. Jordan and Hertlein, Proc. Calif. Acad. Sci., Ser. 4, Vol. 15, No. 14, p. 434, pl. 29, fig. 1, July 22, 1926. "on shore nine miles north of Bernstein's abalone camp, Cedros Island, Lower California; upper Pliocene."
- (465) *Pallium crassicaudo* Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 8, No. 6, p. 313, December, 1856 (apparently issued early in 1857). "Locality. Monterey Co., Cal. A. S. Taylor."—Arnold, U.S.G.S., Prof. Paper 47, p. 71, pl. 16, figs. 1, 1a; pl. 17, figs. 1, 1a, 1b; pl. 18, figs. 1, 2, 2a, 1906. Late Miocene also in early Miocene in southern California.
- (466) Fischer, M. P., "Sur l'Anatomie des Hinnites," Jour. de Conchyl., Vol. 10, No. 3 (Ser. 3, Vol. 2), pp. 205-217, pl. 11, 1862. See also Vol. 11, pp. 144-146, 1863.
- (467) See Dall, W. H., Bull. U.S. Nat. Mus., Vol. 90, p. 134, 1915.
- (468) *Prohinnites* Gillet, Bull. Soc. Hist. Nat. L'Yonne, Vol. 75, (II, Sci. Nat.), p. 94, Ann. 1921 (1922). Type designated by Korobkov (in Osnovy Paleontologii. Spravochnik dlia Paleontologov i Geologov SSSR. Molliuski-Pantzirnye, Dvustvorchatye, Lopatonogie. Otvetsvennyi redaktor toma A. G. Eberzin. Izdatel'stvo Akademii Nauk SSSR, Moskva, p. 84, 1960). Type, *Hinnites leymiereri* Deshayes, 1842.
- (469) See Rollier, L., Abhandl. Schweiz. Paläo. Gesellsch., Bd. 41, pp. 450-466, 1915.
- (470) *Hinnites crassa* Conrad, U.S. Pae. Railroad Survey Expl., Vol. 7, Pt. 2, p. 190, pl. 2, figs. 1, 2, 1856 (1857). "Locality.—Santa Margarita, Salinas Valley."
- (471) *Peeten (Chlamys) multirugosus* var. *crassiplicatus* Gale, Trans. San Diego Soc. Nat. Hist., Vol. 5, No. 9, p. 93, February 29, 1928.
- (472) Arnold, R., U.S.G.S., Prof. Paper 47, p. 91, pl. 29, fig. 1, 1906. (Figure of Conrad's type of *Hinnites crassa*).
- (473) Woodring, W. P., and Stewart, R. B., in Woodring, W. P., Stewart, R. B., and Richards, R. W., U.S.G.S., Prof. Paper 195, p. 70, and list opp. p. 78, pl. 31, figs. 3, 4, 8, 1940 (1941).
- (474) *Hinnites benedicti* Adegoke, Univ. Calif. Publ. Geol. Sci., Vol. 80, p. 103, pl. 3, figs. 3, 5, September 25, 1969.
- (475) Dollfus, G. F., and Dautzenberg, P., Mém. Soc. Géol. France, Paléo., Mém. No. 27, (Vol. 22, Fasc. 2-4), p. 436, 1920.
- (476) Yonge, C. M., Studies on Pacific Coast Mollusks. III. Observations on *Hinnites multirugosus* Gale. Univ. Calif. Publ. Zool., Vol. 55, No. 8, pp. 409-420, figs. 1-6 in text, November 16, 1951.
- (477) Eyerdam, W. J., Nautilus, Vol. 47, No. 1, p. 36, 1933.
- (478) See Bryan, W. A., Natural History of Hawaii, pp. 445, 457, pl. 104, fig. 13, 1915.
- (479) See Henderson, J., Nautilus, Vol. 40, No. 3, p. 81, 1927.
- (480) See Wood, S. V., Palaeontogr. Soc. London, Vol. 27, Supplement to the Monograph of the Crag Mollusca, Part II, Bivalves, p. 102, for 1873, (issued 1874).
- (481) *Propeamussium* de Gregorio, Nat. Siciliano, Anno 3, No. 4, p. 119, January 1, 1894. Sole species, *Pecten (Propeamussium) cecilius* de Gregorio, Sicily, Miocene. See also de Gregorio, Ann. de Géol. et Paléo., Livr. 23, pp. 5, 19, pl. 4, figs. 10-14, 1898.
- (482) *Chlamydeila* Iredale, Rec. Australian Mus., Vol. 17, No. 4, pp. 164, 188, September 4, 1929. "type: *Cyclopecten favius* Hedley," Australian Museum, Mem. 4, Vol. 1, Pt. 5, p. 305, fig. 50, July 29, 1902. "Off Port Kembla in 63-75 fathoms, and off Cape Three Points in 41-50 fathoms," Australia.
- (483) See Barnard, K. H., Ann. South African Mus., Vol. 47, Pt. 3, pp. 421, 433, March, 1964.
- (484) This species was reported from a depth of 860 fathoms by Durham (Nautilus, Vol. 55, No. 4, p. 121, 1942) and from 1720 fathoms by Emerson and Puffer (Amer. Mus. Novitates, No. 1825, p. 18, 1957). Grau (1959, p. 34) stated concerning such specimens, "it is almost certain that they were not living at that great depth."
- (485) *Pecten (Cyclopecten) cocosensis* Dall, Bull. Mus. Comp. Zool., Harvard Coll., Vol. 43, No. 6, p. 405, pl. 6, figs. 1, 3, October, 1908. "U.S.S. 'Albatross,' station 3369, near Cocos Island, Gulf of Panama, in 52 fathoms, rocky bottom, temperature 62.2°F., U.S.N. Mus. 122,870."
- (486) *Cyclopecten acutus* Grau, Allan Hancock Pac. Exped., Vol. 23, p. 31, pl. 10, fig. 2, September 25, 1959. "Off northside of Gorgona Island, western Colombia, in 32 fathoms."
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- (488) See Cox, L. R., Mem. Geol. Surv. India, Palaeont. Indica, Ser. 9, Vol. 3, Pt. 4, pp. 47-49, 1952. See also Cox, Proc. Malacol. Soc. London, Vol. 25, Pts. 5 and 6, pp. 152, 154, 156, 1943.
- (489) According to L. R. Cox (written comm.) this work was issued between September 22 and December 24, 1797.
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- (491) *Promantellum* Iredale, Brit. Mus. (Nat. Hist.) Great Barrier Reef Exped. 1928-1929. Sci. Repts., Vol. 5, No. 6, Moll., Pt. 1, p. 385, February 25, 1939. "Type: *P. parafragile* sp. nov.," p. 386, pl. 6, figs. 10, 10a. "Low Isles," Great Barrier Reef Australia.
- (492) *Submantellum* Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Monogr. No. 8, p. 60, November 6, 1953. "Type: *Lima orbigny* Lamy (*Lima angulata* Sowerby, not Münster)."
- (493) Studnitz, G. von., "Die Morphologie und Anatomie von *Lima inflata*, der Feilenmuschel, nebst biologischen Untersuchungen an *Lima hians* Gmel.," Zool. Jahrb., Abt. Anat., Bd. 53, pp. 199-316, 1931. See also Gilmour, T. H. J., "The defensive adaptations of *Lima hians* (Mollusca, Bivalvia)," Jour. Mar. Biol. Assoc. U. K., Vol. 47, pp. 209-221, pl. 1, figs. 1-5 in text.
- (494) *Lima (Limaria) hemphilli*, Hertlein and Strong, Zoologica, Vol. 31, Pt. 2, No. 5, p. 66, pl. 1, figs. 3, 4, August 20, 1946. "San Diego, California." Recent.
- (495) *Lima orbigny* Lamy, Jour. de Conchyl., Vol. 74, No. 3, p. 180, November 29, 1930. New name for *Lima angulata* Sowerby, 1843, not *Lima angulata* Münster, 1841. See also Hertlein and Strong, Zoologica, Vol. 31, Pt. 2, No. 5, p. 67, 1946.
- (496) *Lima auaua* Dall, Bartsch, and Rehder, Bernice P. Bishop Mus., Bull. 153, p. 106, pl. 27, figs. 5-8, July 25, 1938. Dredged "in Auaua Channel between Maui and Lanai, in 28-43 fathoms on sand and gravel bottom; bottom temperature, 74.0°F."
- (497) Cited as Family "Ostraceae" by Oken, 1818; also as "Fam. Ostracea" by Goldfuss, 1820; as "Division" "Ostraceae" by Bowdich, 1822; as "Ostraceae" by Parkinson, 1822; as "Order Ostreidae" by Fleming, 1822; as "Fam. I-Ostracés Ostracea" by Deshayes, 1824.
- (498) "Ostreacia" Rafinesque, 1815, p. 21. Corrected to Ostreidae. See Internatl. Comm. Zool. Nomencl., Opinion 356, signed February 8, 1955, published August 12, 1955.
- (499) Newell, N. D., "Origin of the oysters," Bull. Geol. Soc. Amer., Vol. 71, No. 12, Pt. 2, p. 1936, 1960. See also, Report Internatl. Geol. Congr. XXI Session, Norden, 1960, Part XXII, Internatl. Paleon. Union, 1960, Copenhagen, pp. 81-86, 1 fig.
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- (501) Baughman, J. L., Annotated bibliography of oysters, with pertinent material on mussels and other shellfish, and an appendix on pollution, Texas A. and M. Res. Found., College Station,

Texas, 794 pp., 1947.

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(510) "*Ostrea* var. *laticaudata*, Nutt. MS," Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 646, issued August, 1864. Indicated as from "Neighborhood of S. Francisco." Reprint in Smithsonian Misc. Coll., No. 252, p. 122, 1872. See also *Ostrea lurida* forma *laticaudata* Carpenter, Hertlein, Veliger, Vol. 2, No. 1, p. 7, pl. 2, figs. 7, 8, 1959. San Pedro, California, Recent.

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(513) See Durham, J. W., Geol. Soc. Amer., Mem. 43, Pt. 2, p. 58, 1950 (as *Ostrea cumingiana*). See also, Emerson, W. K., and Hertlein, L. G., 1964, pp. 349, 353.

(514) Willett, G., Bull. South. Calif. Acad. Sci., Vol. 45, Pt. 1, p. 29, 1946.

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(516) See Vokes, H. E., in Wilson, I. F., Bull. Amer. Assoc. Petrol. Geol., Vol. 32, No. 9, p. 1782, 1948. Also U.S.G.S., Prof. Paper 273, p. 32, 1955.

(517) *Ostrea* *canchaphila*, var. *palmula* Carpenter, Cat. Mazatlan Shells, pp. 163, 550. March, 1856. "Mazatlan; extremely rare; L'pool Col. -S. W. Mexico. P. P. C.-Upper California, Nuttall." See also Hertlein and Strong, Zoologica, Vol. 31, Pt. 2, p. 55, pl. 1, fig. 14, 1946 (as *Ostrea palmula*). Illustration of interior of upper (right) valve of type specimen. Various localities cited. See also Keen, A. M., Sea Shells of Tropical West America, p. 66, fig. 124 (p. 69), 1958; and Olsson, 1961, p. 173, pl. 17, figs. 6, 6a; pl. 23, figs. 5, 5a, 7, 7a.

(518) *Ostrea vespertina* Conrad var *sequens* Arnold, U.S.G.S., Bull. 396, p. 79, pl. 29, figs. 5, 6, 1909 (issued January 15, 1910). From Loc. 4728, "just below *Anodonta* bed on northeast border of Kettleman Hills, nearly 6 miles east-southeast of northwest end, in north part of sec. 35, T. 21 S., R. 17 E." "Horizon.—Extreme top of the Etchegoin formation, upper Miocene, just below Tulare bed (*Anodonta* fresh-water bed)." See also Woodring, in Woodring, Stewart, and Richards, 1940 (1941), p. 92, pl. 8, figs.

10-14.

(519) *Ostrea canchaphila* Carpenter, Cat. Mazatlan Shells, p. 161, 1855. "Hab.—Mazatlan; not uncommon, on various shells," also other localities. See also Hertlein, L. G., and Strong, A. M., Bull. Amer. Mus. Nat. Hist., Vol. 107, Art. 2, p. 179, pl. 3, figs. 29, 30, 1955. Redondo, California, to the Gulf of California and south to Panama.

(520) *Ostrea lurida* Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, pp. 599, 606, 615, 645, issued August, 1864. Cited from various localities including Vancouver Island, Puget Sound, Oregon, and near San Francisco. See also Palmer, K. V. W., Geol. Soc. Amer., Mem. 76, p. 66, pl. 5, figs. 4-6, 1958. "Recent. [Cape] Shoalwater ['Bay'] northern Willapa Harbor, Washington (type)."

(521) See Hertlein, L. G., The Veliger, Vol. 2, No. 1, pp. 6, 7, pl. 2, figs. 1, 2 (typical), 3, 6, 7, 8, 9, 11 (vars.), 1959.

(522) *Ostrea heermanni* Conrad, Proc. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 267, February, 1855. "Colorado Desert. Dr. Heermann. Shell silicified."—Hanna, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 18, p. 467, pl. 22, figs. 7, 8; pl. 23, figs. 1, 2, 1926.

(523) *Ostrea sculpturata* Conrad, Fossils of the Medial Tertiary of the United States, No. 2, p. 50, pl. 25, fig. 3, May 7, 1840. "James river, near Smithfield, Va." See also reprint by Wagner Free Inst. Sci., 1893.

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Tikonovich (Mém. du Comité Géol. Nouv. Sér., Livr. 82, p. 39, 1914) cited this species as occurring in Tertiary strata in the Schmidt Peninsula, North Sakhalin, but that record is almost certainly referable to some other species.

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(Identification by J. Gardner.)

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(838) Etherington cited "*Cardium (Cerastoderma) cf. corbis* Martyn" from beds of middle Miocene age in southwest Washington (Univ. Calif. Publ. Geol. Sci., Vol. 20, No. 5, p. 77, pl. 5, fig. 11, 1931), and Moore recorded *Clinocardium* aff. *C. nuttallii* Conrad from strata of middle Miocene age in Oregon (U.S.G.S., Prof. Paper 119, p. 73, pl. 30, figs. 1, 2, 1963). Keen (Bull. Amer. Paleo., Vol. 35, No. 153, p. 323 (17), 1954) believed that Etherington's record might be referable to either *Clinocardium pristinum* Keen or perhaps to an unnamed species.

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- (892) *Katherinella* Tegland, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 18, No. 10, p. 280, May 8, 1929. "Genotype.—*Calloallista arnoldi* Weaver," Univ. Washington Publ. Geol., Vol. 1, No. 1, p. 40, pl. 2, fig. 13, February, 1916 (as *Calloallista arnoldi*). "in railways cuts on the O.-W. R. R. & N. Co. one fourth mile north-west of Lincoln Creek Station in Section 27, Township 15 North, Range 3 West." "Lowermost Oligocene; *Molopophorous lincolniensis* zone." See also discussion of the genus *Katherinella* by Stenzel, Krause, and Twining (Univ. Texas, Bull. Bur. Econ. Geol., No. 5704, pp. 133-135, 1957) and by Moore, Ellen J. (U.S.G.S., Prof. Paper 419, pp. 76-77, 1963).
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- (903) See Travis, R. B., Calif. State Div. Min., Bull. 162, p. 21, 1952.
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(930) *Venus asperima* Sowerby, Proc. Zool. Soc. London for 1835, p. 42, June 1, 1835. "Hab. ad Insulam Lobos dictam." "Found in fine sand at low water."—Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 307, pl. 53, figs. 3, 3a; pl. 54, fig. 6, 1961 (as *Nioche* (*Nioche*) *asperima asperima*). Guaymas, Sonora, Mexico.

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(932) *Chione semiplicata* Nomland, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 10, No. 18, p. 305, pl. 15, figs. 2a, 2b, 2c, November 8, 1917. "From locality 2283, in small gully near SE corner of NW ¼ of Sec. 15, T. 19 S., R. 15 E., M.D.B. & M., about nine miles northeast of Coalinga." Santa Margarita Formation, late Miocene.

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(934) *Chione panzana* Anderson and Martin, Proc. Calif. Acad. Sci., Ser. 4, Vol. 4, p. 58, pl. 1, figs. 1a, 1b, December 30, 1914. "San Luis Obispo County, California, in a small creek about ¾ of a mile southwest of Lewis House, near the center of the S.E. ¼ of Sec. 22, T. 29 S., R. 16 E., Mt. D.B.L. and M." "Lower Miocene."

(935) See Parker, P., Jour. Paleo., Vol. 23, No. 6, p. 592, November, 1949.

(936) *Chione vickeryi* Wiedey, Jour. Paleo., Vol. 3, no. 3, p. 286, pl. 32, fig. 4, September, 1929. "Collected 500 yards upstream from the falls in Alum Rock Canyon, just east of San Jose, Santa Clara County, California." "Upper Monterey formation, middle Miocene."

(937) *Chione schencki* Loel and Corey, Univ. Calif. Publ. Bull. Dept. Geol. Sci. Vol. 22, No. 3, p. 224, pl. 42, fig. 5, December 21, 1932. "from buff calcareous sandstone at head of Corral de Piedra Creek, about five miles east of San Luis Obispo." [Cited from beds of early Miocene age but according to Parker (p. 584) the type bears the same locality number as *C. vickeryi* and "It is obviously not a Vaqueros species."]

(938) *Chione elsmereensis* English, Univ. Calif. Publ. Bull. Dept.

Geol., Vol. 8, No. 8, p. 214, pl. 23, figs. 1a, 1b, November 7, 1914. "From lower Fernando, Elsmere Cañon. Univ. Calif. Loc. 1735."

(939) Hertlein, L. G., Stanford Univ. Bull., Ser. 5, No. 78, pp. 84, 85, 1929. San Diego Pliocene.

(940) *Chione fernandoensis* English, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 8, No. 8, p. 215, pl. 23, figs. 9a, 9b, November 7, 1914. "Elsmere Cañon, Univ. Calif. Loc. 1602" (p. 218). "Lower Fernando," Pliocene.

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(943) *Venus mariae* d'Orbigny, Voy. Amér. Mérid., Vol. 5, p. 563, 1846. "M. Cuming l'a pechée à l'île de la Plata, sur les cotes de la république de l'Equateur." New name for *Venus cypria* Sowerby, 1835, not *Venus cypria* Brocchi, 1814, nor *Venus cypria* Risso, 1826. Illustrated by Reeve, Conch. Icon., Vol. 14, *Venus*, sp. 116, pl. 23, figs. 116a, 116b, 1863.

(944) "*Paphia* cf. *staleyi* (Gabb)" was reported from the "Temblor Horizon" by Loel and Corey (Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 22, No. 3, p. 145, 1932).

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(946) Marwick, J., New Zealand Jour. Sci. Tech., Vol. 8, no. 5, p. 272, 1926.

(947) Hatai, K., and Nisiyama, S., Sci. Repts. Tohoku Univ. Sendai, Japan, Second Ser. (Geol.), Special Vol. 3, p. 132, 1952.

(948) *Novathaca* Habe, Gen. Jap. Shells, Pelecypoda No. 2, p. 180, September, 1951. "Type species: *Chione euglypta* Sowerby."

(949) *Tropithaca* Olsson, "Mollusks of the Tropical Eastern Pacific" (Paleo. Res. Inst.: Ithaca, New York), p. 305, March 10, 1961. "Type species *Protothaca grata* (Say)." Illustrated on pl. 53, figs. 2-2b, 7.

(950) *Tuanguia* Marwick, Trans. New Zealand Inst., Vol. 57, p. 623, February 12, 1927. "Type: *Venus crassica* Deshayes," pl. 49, figs. 178, 181, 182.

(951) See Gale, H. R., in Preston, H. M., Summ. Oper. Calif. Oil Fields, Vol. 16, no. 4, p. 15, April, May-June, 1931. Woodring, Bramlette, and Kew (1946, p. 27) reported "*Callithaca*? cf. *C. staminea* (Conrad)" from the "middle part of Altamira shale member of Monterey shale," of probable middle Miocene age.

(952) *Protothaca kovatschensis* Ilyina, Trudy Vsesoiuznogo Neftianogo Nauchno-issledovatel'skogo Geologorazvedochnogo Inst. (VNIGRI) (Moskva), Vypusk 202, p. 52, pl. 18, fig. 8, 1963.

(953) See Smith, G. M., "Further observations on the ecology, rate of growth and food supply of some Pacific clams." Trans. Roy. Soc. Canada, Ser. 3, Vol. 27, sec. 5, pp. 229-245, figs. 1-5 in text, 1 map, 1933.

(954) W. O. Addicott and J. G. Vedder (U.S.G.S., Prof. Paper 475C, p. C67, 1963) reported "*Protothaca* cf. *P. tenerrima*" from the Santa Margarita Formation of late Miocene age at Comanche Point, Kern Co., California.

(955) *Paphia restorationensis* Frizzell, Nautilus, Vol. 43, No. 4, p. 120, April, 1930. "Fairly common in late Pleistocene beds at Restoration Point, near Port Blakely, Washington, and extremely rare living in Puget Sound."—Frizzell, Trans. San Diego Soc. Nat. Hist., Vol. 6, No. 21, p. 321, pl. 22, figs. 1, 2, 3, 4, April 30, 1931.

(956) *Irus* Oken, Lehrbuch Zool., p. 230, 1815. Type (by tautonymy): *Donax irus* Linnaeus [Syst. Nat., ed. 10, p. 683, 1758. "Habitat in M. Mediterraneo." Ref. to "Gault. test. t. 95. f.A."] Illustrated by Bucquoy, Dautzenberg, and Dollfus, Moll. Mar. Roussillon, Vol. 2, Fasc. 9 (Pelecypoda Fasc. 22), p. 438, pl. 67, figs. 9-18, 1893. See also *Venerupis irus* Linnaeus, Cossmann and Peyrot, Act. Soc. Linn. Bordeaux, Vol. 65 (Conch. Néog. l'Aquitaine Vol. 1, Livr. 3), fig. 81, p. 432 (hinge), p. 433, pl. 19, figs. 1-6, 1911. For a discussion of this species see Dodge, Bull.

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- (958) *Notirus* Finlay, Trans. Proc. New Zealand Inst., Vol. 59, Pt. 2, p. 278, issued August 31, 1928. A new name for *Irona* Finlay, 1926. Not *Irona* Mabile, 1883; not *Irona* Schiödte & Meinert, 1884.
- (959) *Paphonotia* Hertlein and Strong, Zoologica, Vol. 33, Pt. 4, No. 13, p. 192, December 31, 1948. "Type: *Petricola elliptica* Sowerby, 1834." Illustrated by Keen, Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), p. 138, fig. 313, 1958.
- (960) This species was reported from beds of Pleistocene age at Punta China, Lower California (see Emerson, W. K., Bull. Amer. Mus. Nat. Hist., Vol. 111, Art. 4, p. 339, 1956).
- (961) *Irus lamellifer* (Conrad) variety *prelamellifer* Grant and Gale, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 332, pl. 18, fig. 7, November 3, 1931. "Pacific Eastern Production Company's well No. 1, KCL-B, Sec. 21, T. 29 S., R. 27 E., Fruitvale District, Kern County, near Bakersfield, California, depth 4859 feet, upper (possibly middle) Miocene."
- (962) See *Venerupis multicostata* Turton, Mar. Shells of Port Alfred, South Africa, p. 245, No. 1731, pl. 66, fig. 1731, 1932.
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- (1007) *Tellina kesenensis* Nomura and Hatai, Saito Ho-on Kai Mus., Res. Bull. No. 5, p. 14, pl. 1, figs. 1a, 1b, 1935. "Hanagai," northeast Honsyū, Japan, Recent.
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- (1013) *Tellina (Peronidia) nitida* Poli, Cossmann and Peyrot, Act. Soc. Linn. Bordeaux, Vol. 64 (Conch. Néog. de l'Aquitaine, Tome 1, Livr. 2), p. 244, pl. 9, figs. 6, 7, 1911.
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- (1015) See *Tellina (Peronidia) bodegensis* Hinds n. subspecies?, Clark and Arnold, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 14, No. 5, p. 149, pl. 22, figs. 7, 8, November 6, 1923. Loc. 231 (CAS), "In the sea cliffs east of the mouth of Kirby Creek, 6 miles west of Sooke, Vancouver Island."
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(1155) Hertlein, L. G., and Strong, A. M., Eastern Pacific Expeditions of the New York Zoological Society. XLII. Mollusks from the West Coast of Mexico and Central America. Part IX. Zoologica, Vol. 35, Pt. 4, Family Mactridae, pp. 229-236, pl. 2, December 30, 1950.

(1156) See Keen, A. M., Sea Shells of Tropical West America (Stanford Univ. Press: Stanford, California), pp. 154-162, 1958.

(1157) See Olsson, A. A., Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), pp. 320-336, 1961.

(1158) Adapted in part from Keen, 1963.

(1159) Not represented in the present collection.

(1160) See discussion by T. A. Burch, in Burch, J. Q., Min. Conch. Club South. Calif., No. 44, pp. 8-16, February, 1945; No. 49, pp. 50-51, June, 1945.

(1161) *Spisula albaria* Con. var. *coosensis* Howe, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 14, No. 3, p. 99, pl. 9, figs. 6, 7, September 8, 1922. The type is from the "Empire formation, Coos Bay, Oregon." Pliocene. This form was illustrated by Dall, U.S.G.S., Prof. Paper 59, pl. 10, fig. 1, 1909.

(1162) Howe stated that the angulation extends to the "anterior" ventral margin but Conrad's illustration shows a distinct posterior umbonal angulation.

(1163) See Weaver, C. E., Univ. Washington Publ. Geol., Vol. 5, Part 1, p. 239, December, 1942 (issued December 31, 1943). See discussion by Ellen J. Moore, U.S.G.S., Prof. Paper 419, p. 83, 1963.

(1164) See Dall, W. H., Proc. Malacol. Soc. London, Vol. 1, No. 5, p. 211, March, 1895.

(1165) See Dall, W. H., U.S. Nat. Mus., Bull. 112, p. 52, 1921.

(1166) *Hemimactra* Swainson, Treatise on Malacol., p. 369, 1840. Species cited, "*H. gigantea* Lam. v. 472, No. 1, *grandis* Sw. Sp. Nov." Type designated by Gray (Proc. Zool. Soc. London for 1847, p. 185): "*M. gigantea*." This is believed to be identical with *Mactra solidissima* Chemnitz, 1788, the hinge of which was well illustrated by Lamy (Jour. de Conchyl., Vol. 63, No. 4, p. 292, 1918).

- (1167) See Woodring, W. P., in Woodring, W. P., and Bramlette, M. N., U.S.G.S., Prof. Paper 222, p. 88, 1950.
- (1168) *Spisula catilliformis* Conrad, var. *alcatrazensis* Arnold, Smithsonian Miscell. Col. (Quart. Issue), Vol. 50, Pt. 4, No. 1781, p. 437 (separate p. 19), pl. 56, fig. 6, December 13, 1907. "Alcatraz asphalt mine, near Sisquoc, Santa Barbara County, California; locality No. 4471." "Fernando formation, lower Pliocene portion."
- (1169) Addicott cited records of *Spisula falcata* from the Tehana Member, lower portion of the Purisima Formation in Portola Valley in San Mateo County, California (Proc. Calif. Acad. Sci., Ser. 4, Vol. 37, No. 3, p. 83, 1969).
- (1170) *Spisula falcata brioniana* Trask, Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 13, No. 5, p. 152, pl. 4, figs. 2a, 2b, May 10, 1922. "U.C. loc. no. 3522," 283 mm. east and 210 mm. south of the northwest corner of the Concord quadrangle topographic sheet, California. According to Keen and Bentson (Geol. Soc. Amer., Spec. Papers 56, p. 109, 1944) this locality is "N $\frac{1}{2}$ 1, T 1 S, R. 2 W," Contra Costa Co., California.
- (1171) *Spissula dolabriformis* Conrad, Amer. Jour. Conch., Vol. 3, Pt. 2, p. 193, September 5, 1867. "Inhabits Panama." (Cited under "*Spisula*" in Vol. 3, Pt. 3, Ap., p. 44, 1868).—Conrad, Amer. Jour. Conch., Vol. 5, Pt. 2, p. 108, pl. 12, fig. 1, 1869. [Smaller figure only].—T. A. Burch, Min. Conch. Club South. California, No. 49, p. 50, pl. 3, figs. 32 and 33 (type), 40, June, 1945 (as *Spisula dolabriformis*).—Olsson, Mollusks of the tropical eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 325, pl. 57, figs. 1, 1a; pl. 58, figs. 4, 4a, 1961 (as *Maetra* (*Mactromeris*) *dolabriformis*).
- (1172) The reported occurrence of this species at Corinto, Nicaragua, by Eyerdam was based upon one specimen (see Pacific Northwest Shell News, Vol. 2, No. 4, p. 55, July, 1962).
- (1173) Record from this locality was based upon a right valve 42 mm. long (ventral portion imperfect), from the Mackenzie-Gordon collection now in the California Academy of Sciences.
- (1174) *Spisula cameronis* Dall, West Amer. Sci., Vol. 19, No. 3, p. 22, June 15, 1921. "Pliocene (or early Pleistocene) of San Quentin Bay, Lower California."—Dall, Proc. U.S. Nat. Mus., Vol. 66, Art. 17, No. 2554, p. 26, pl. 10, fig. 2; pl. 11, fig. 4, 1925. "Pliocene (?) of San Quentin Bay, Lower California."
- (1175) *Spisula* (*Hemimaetra*) *massbeachensis* Glen, Univ. Calif. Publ. Geol. Sci., Vol. 36, No. 2, p. 175, pl. 15, fig. 8; pl. 16, fig. 1, November 23, 1959. "'Merced' formation of Pillar Point," Pliocene.
- (1176) *Spisula longa* Dall, West Amer. Sci., Vol. 19, No. 3, p. 22, June 15, 1921. "Pliocene (or early Pleistocene) of San Quentin Bay, Lower California."—Dall, Proc. U.S. Nat. Mus., Vol. 66, Art. 17, No. 2554, p. 27, pl. 10, fig. 1; pl. 11, fig. 3, 1925. "Pliocene (?) of San Quentin Bay, Lower California."
- (1177) *Spisula* (*Mactromeris*) *hemphilli* var. *arcutti* Manger, Johns Hopkins Univ. Studies in Geol., No. 11, p. 301, pl. 21, Figs. 5, 6, 1934. "San Quentin Bay," Lower California, Pleistocene.
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- (1179) *Spisula strongi* T. A. Burch, Min. Conch. Club South. Calif., No. 49, p. 50, pl. 3, figs. 35-39, June, 1945. "Newport Bay, Calif." Recent.
- (1180) See Woodring, W. P., in Woodring, W. P., and Bramlette, M. N., U.S.G.S., Prof. Paper 222, p. 88, 1950.
- (1181) *Spisula sisquocensis* Arnold, Smithsonian Misc. Coll. (Quarterly Issue), Vol. 50, Pt. 4, No. 1781, p. 437 (separate p. 19), pl. 56, fig. 1, December 13, 1907. "Alcatraz asphalt mine, near Sisquoc, Santa Barbara County, California; locality No. 4471." "Fernando formation, lower Pliocene portion."
- (1182) *Mactrotoma revellei* Durham, Geol. Soc. Amer., Mem. 43, Pt. 2, p. 93, pl. 25, figs. 1, 5, August 10, 1950. "Loc. A 3548 and Recent, Gulf of California." (Loc. A 3548 = Pleistocene of Coronado Island, Gulf of California. *Porites* reef bed overlying algal sandstone.)
- (1183) See Burch, T., Min. Conch. Club South. Calif., No. 44, pp. 8, 17, 18, 21-22, February, 1945.
- (1184) Hertlein, L. G., and Strong, A. M., Eastern Pacific Expeditions of the New Zoological Society. XLII. Mollusks from the West Coast of Mexico and Central America. Part IX., Zoologica, Vol. 35, Pt. 4, p. 230, 1950.
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- (1187) The writers are grateful to Mr. W. I. Follett, Department of Ichthyology, California Academy of Sciences and to the late Harriet Exline (Mrs. Don L. Frizzell), Rolla, Missouri, for advice concerning the problem of *Schizothaerus* versus *Tresus*.
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- (1192) *Lutraria capax* Gould, Proc. Boston Soc. Nat. Hist., Vol. 3, p. 217, May, 1850. "Hab. Puget Sound."—Gould, U.S. Explor. Exped. (Wilkes), Vol. 12, Moll., p. 395, 1852, Atlas, p. 13, pl. 34, figs. 508, 508a, 508h, 1856.
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(1203) Lamy, E., "Révision des Myidae vivants du Muséum National d'Histoire Naturelle de Paris," Jour. de Conchyl., Vol. 70, No. 3, pp. 151-185, figs. 1-8 in text, February 25, 1927.

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(1205) Fujie, T., "On the Myarian Pelecypods of Japan. Part 1. Summary of the Study of the Genus *Mya* from Hokkaido," Jour. Fac. Sci. Hokkaido Univ., Ser. IV. Geol. Min., Vol. 9, No. 4, pp. 381-413, pls. 1-8, figs. 1-4 in text, December, 1927; Pt. 2, Vol. 11, No. 3, pp. 399-430, figs. 1-10 in text, March, 1962.

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(1210) See Burch, J. Q., Min. Conch. Club South. California, No. 44, p. 26, February, 1945.

(1211) *Mya* (*Cryptomya*) *incognita* Clark, Univ. Calif. Publ. Bull. Dept. Geol., Vol. 11, No. 2, p. 160, pl. 11, fig. 8; pl. 14, fig. 4, July 16, 1918. From U.C.C. Loc. 1131 = "½ mile SW of town of Walnut Creek; in creek bed about 100 yards to the E of Oakland and Antioch bridge; elevation 150 feet; Contra Costa Co., long. 122°48', lat. 37°53'7'."

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(1214) See *Cryptomya oregonensis* Dall, Weaver, Univ. Washington Publ. Geol., Vol. 5, Pt. 1, p. 252, pl. 59, fig. 4, 1942 (issued December 31, 1943). "Type locality. Fossil Point, Coos Bay, Oregon." Geol. range, "Empire formation, upper Miocene and lower Pliocene."

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(1234) *Corbula speciosa* Reeve, Conch. Icon., Vol. 2, *Corbula*, sp. 6, pl. 1, fig. 6, August, 1843. "Hab. Gulf of Nicoya (dredged in seven fathoms water)." A new name for *Corbula radiata* Sowerby, 1833, not *Corbula radiata* Brocchi, 1814.—Olsson, Mollusks of the Tropical eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 438, pl. 77, figs. 7, 7a, 7b, 7c, 1961 (as *Varicorbula speciosa*). Gulf of California to the Gulf of Nicoya, Costa Rica.

(1235) *Corbula nuciformis* Sowerby, Proc. Zool. Soc. London, for 1833, p. 35, issued May 17, 1833. "Hab. in América Centrali." "Found at a depth of six fathoms in a sandy mud at Real Llejos."—Hertlein and Strong, Zoologica, Vol. 35, Pt. 4, p. 241, pl. 2, fig. 1, 1950 (as *Aloidis* (*Caryocorbula*) *nuciformis*).

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(1237) *Corbula* (*Varicorbula*) cf. *bradleyi* Nelson, Olsson, Bull. Amer. Paleo., Vol. 27 (106), p. 197 (45), 1942. "Quebrada Mellisa," Panama, Pliocene.

(1238) *Corbula biradiata* Sowerby, Proc. Zool. Soc. London for 1833, p. 35, issued May 17, 1833. "Hab. ad Chiriqui et ad sinum caraccensem." "Found in mud and sand in from three to six fathoms at Chiriqui, and in seven fathoms in the Bay of Caraccas."—Reeve, Conch. Icon., Vol. 2, *Corbula*, species 3, pl. 1, fig. 3, 1843.—Hertlein and Strong, Zoologica, Vol. 35, Pt. 4, p. 238, 1950 [as *Corbula* (*Caryocorbula*) *biradiata*].

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- (1247) See Dell, R. K., *Discovery Repts.*, Vol. 33, pp. 222-226, 1964.
- (1248) *Mytilus pholadis* Linnaeus, Mantissa, 2, p. 548, 1771. "Habitat in Oceano septentrionalis."—Chemnitz, Neues Syst. Conchyl.-Cab., Bd. 8, p. 154, pl. 82, figs. 735, 735b, 1785.—I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 209, pl. 51, fig. 5, 1924 (as *Saxicava pholadis*). See also illustrations by Sowerby in Reeve, 1878, and by Sars, 1878.
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(1360) *Poromya* Forbes, Rept. Brit. Assoc. Adv. Sci. for 1843, p. 191, issued 1844. Sole species, *Poromya anatinoides* Forbes, p. 191. "Asia Minor, Cyclades," Aegean Sea, Recent.—Dall, Proc. U.S. Nat. Mus., Vol. 12, No. 773, p. 289, 1889 (issued March 7, 1890).—Dall, Bartsch, and Rehder, Bernice P. Bishop Mus., Bull. 153, p. 223, 1938. "Type: *Poromya anatinoides* Forbes. ? = *granulata* Nyst and West[endorp] (by monotypy)."—See also, Olsson, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 467, 1961.

(1361) See Lamy, E., Comp. Rend. Congrès Soc. Savantes, Paris, 1925, p. 505.

(1362) See Odhner, N. H.—J., Mollusca, in Repts. Swedish Deep-Sea

Exped. 1947-1948, Vol. 2, Fasc. 4, Zool., No. 22, pp. 377-379, November, 1960.

(1363) *Poromya gabbiana* Anderson and Martin, Proc. Calif. Acad. Sci., Ser. 4, Vol. 4, p. 56, pl. 3, figs. 7a, 7b, December 30, 1914.

(1364) See Keen, A. M., and Bentson, H., Geol. Soc. Amer., Spec. Papers No. 56, p. 103, 1944.

(1365) See Tegland, Nellie M., Univ. Calif. Publ. Bull. Dept. Geol. Sci., Vol. 23, No. 3, p. 92, 1933.

(1366) Addicott, W. O., Jour. Paleo., Vol. 40, No. 3, pp. 644, 645, May, 1966.

(1367) See Clark, A., Trans. San Diego Soc. Nat. Hist., Vol. 7, No. 4, table opposite p. 30, 1931.

(1368) *Poromya (Dermatomya) equatorialis* Dall, Bull. Mus. Comp. Zool., Vol. 43, No. 6, p. 429, pl. 5, figs. 1, 2, October, 1908. "U.S.S. 'Albatross,' station 3360, Gulf of Panama, in 1672 fathoms, sand, bottom temperature 42° F.; U.S.N. Mus. 122, 942. Also at station 2793, off the coast of Ecuador, in 741 fathoms, mud, temperature 38.4° F."

(1369) *Poromya (Dermatomya) soyoae* Habe, Gen. Jap. Shells, No. 3, p. 273, figs. 724, 728, May, 1952. [Name and figures only.]—Habe, Illustr. Cat. Jap. Shells, No. 21, p. 158, pl. 22, figs. 7, 8, November 30, 1952 (as *Dermatomya tenuiconcha soyoae*). "Type locality: Off Hachinohe City Aomori Pref., (Sōyō-maru St. No. 71, 444 m. in depth); off Kuji, Iwate Pref. (St. 62, 611 m. in depth); off Kinkazan, Miyagi Pref. (St. 33, 331 m. depth), Honshu."

(1370) *Dermatomya (tenuiconcha* Dall, 1913, var.?) *sagamiensis* Okutani, Bull. Tokai Reg. Fish. Res. Lab., Tokyo, Japan, No. 32, p. 32, pl. 3, fig. 3; pl. 5, figs. 8, 8a, January, 1962. Type locality: "Sagami Bay, 700-750 m."

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(1372) See Conrad, T. A., "Catalogue of the Family Anatinidae," Amer. Jour. Conch., Vol. 4, Pt. 5, *Neaera*, pp. 56-58, 1869.

(1373) Kuroda, T., "Studies on Japanese species of *Cuspidaria*," Jap. Jour. Malacol., Vol. 15, Nos. 1-4, pp. 1-28, pls. 1 and 2, 1948.

(1374) *Cuspidaria (Cardiomya) californica* Dall, Bull. Mus.

Comp. Zool., Vol. 12, No. 6, p. 296 (footnote), September, 1886. "Habitat. Catalina Island, California, dredged in 16 fms., mud; Dall, and previously Cooper, who confounded it, following Carpenter, with *pectinata*."—I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 101, pl. 5, fig. 14; pl. 34, fig. 3, 1924. Puget Sound to San Diego, California.

(1375) See "*Cuspidaria (Cardiomya) oldroydi* n. sp., Dall" in I. S. Oldroyd, Publ. Puget Sound Biol. Sta., Vol. 4, p. 33, pl. 1, fig. 13, March, 1924. "Lopez Island, Wash.; Puget Sound.—Vancouver Island to Puget Sound."—I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 1, p. 101, pl. 5, fig. 13, 1924. "Type locality, Puget Sound."

(1376) See Vedder, J. G., U.S.G.S., Prof. Paper 400 B, p. B326, 1960.

(1377) See Simonova, A. A., Trans. Geol. Oil Inst., New Ser., Fasc. 18, p. 29, pl. 10, fig. 1, 1941.

(1378) Kuroda, T., "On the Verticordiidae from Japan," Venus, Vol. 17, No. 1, pp. 6-16, pl. 1 (figs. 1-18), and figs. 19, 20 (p. 15), July, 1952.

(1379) See Iredale, T., Rec. Australian Mus., Vol. 17, No. 9, pp. 387-388, June 27, 1930.

(1380) See Soot-Ryen, T., Sarsia, No. 24, pp. 15-27, pls. 1-3, figs. 11-13 in text, April, 1966.

(1381) See *Verticordia granulosa* Ravn, Kon. Dan. Vidensk. Selskab., Biol. Skr., Bd. 1, Nr. 1, p. 39, pl. 1, figs. 12 a-b, 13, 14 a-b, 1939. "Paléocène de Copenhague."

(1382) Fischer, P., "Note sur les genres *Hippagus* et *Verticordia*," Jour. de Conchyl., Vol. 8 (2nd Ser., Vol. 4), pp. 295-300, 1860; also Vol. 10, pp. 378-381, 1862.

(1383) *Verticordia acquicostata* Howard, Nautilus, Vol. 63, No. 4, p. 109, pl. 7, 2 figs., April, 1950. Type "from north of Angel La Guardia Island, 90 fathoms." [Gulf of California.]

(1384) *Verticordia perplicata* Dall, Proc. U.S. Nat. Mus., Vol. 12, No. 773, p. 278, pl. 8, fig. 1, issued March 7, 1890. "Hab.—U.S. Fish Commission Station 2807, in 812 fathoms, mud, near the Galápagos Islands; bottom temperature 38°.4 F."

LIST OF LOCALITIES

CALIFORNIA ACADEMY OF SCIENCES

104. Sea cliff about three miles south of La Jolla, Pacific Beach.
105. Along the west margin of the peninsula which extends into False Bay from the north, Pacific Beach, San Diego.
547. Fossils from beach cliff north of Pacific Beach, San Diego.
957. Pacific Beach, upper 5 to 15 feet beneath unconformably overlying Pleistocene beds.
1129. Reynard Way off State Street, San Diego.
1130. San Diego, unlocalized.
1132. Upper beds in Pliocene section at Pacific Beach. [= SD Loc. 34]
1135. Between Reynard Way and Union Street, San Diego.
1136. South of organ in Balboa Park, San Diego.
1137. 31st Street and Logan Avenue, San Diego.
1138. Pacific Beach, San Diego.
1140. Sweetwater Hills, one half mile west of water pipe house.
1141. 32nd and Woolman, San Diego.
1155. Beds from top of hill to oyster bed at Locality 1154. Highest beds on hill west of dike. Top of ridge above San Augustine Canyon east side. About 9.6 Kilometers (6 miles) south of ranch house. Santa Rosa Island, California.
1176. Fossiliferous beds exposed on road going up hill 0.3 mile (.48 kilometer) north of San Diego well which was located at foot of Ash Street in valley of canyon below Russ School.
1177. Road cut on west side of hill just east of corner of Haines Street and Tourmaline Avenue, Pacific Beach.
1178. At foot of Diamond Street, Pacific Beach. [= SD Loc. 21]
1179. Upper beds of lower portion of Pliocene section exposed at Pacific Beach.
1181. South slope of Mt. Soledad, above middle part of gulch, altitude about 140 feet, about 1/3 mile (first gulch) west of Rose Canyon. [= SD Loc. 4 and 80]
1182. At elevation of about 90 feet in first gulch, 300-400 yards west of mouth of Rose Canyon, south slope of Mt. Soledad.
1183. Eagle Street just north of Quince Street, just east of Reynard Way, San Diego.
1186. Cliffs on east side of Reynard Way near mouth of canyon, 100 yards off main highway, where brickyard was located. [= SD Loc. 27]
1199. Pacific Beach, San Diego.
1399. 100 to 200 yards south of Eocene-Pliocene contact at Pacific Beach.
1400. Upper beds in Pliocene section at Pacific Beach, near Loc. 957 (CAS). [= SD Loc. 150]
1401. First canyon west of Rose Canyon on south slope of Mt. Soledad.
1402. About 100 m south of the west end of Laurel Street bridge across Cabrillo Canyon, on point between Cabrillo Canyon and a gulch running into the canyon, Balboa Park, San Diego. [= SD Loc. 29]
1404. Southeast corner of India and Upas Streets, San Diego. [= SD Loc. 75]
1413. Beds of lower portion of Pliocene section exposed at Pacific Beach.
1414. Beds in middle portion of Pliocene section exposed at Pacific Beach.
1415. Road cut north of bridge over 26th Street canyon, San Diego.
1418. Northeast corner of Spruce and Thorn streets, San Diego. [= SD Loc. 38 and 79]
1419. Northeast corner of India and Thorn streets, San Diego. [= SD Loc. 34]
2015. Pacific Beach, San Diego.
2020. Pacific Beach, San Diego.
2028. Cliffs north of Pacific Beach, San Diego.
12051. San Diego, unlocalized.
12053. Pacific Beach, San Diego.
12078. San Diego well.
12096. San Diego, Calif. (H. Hemphill) ["apparently from well in Balboa Park, San Diego, Cal."].
12099. Well at San Diego.
12107. Well at San Diego in Balboa Park.
12142. San Diego, unlocalized.
12145. Cedros Island.
12147. San Diego, unlocalized.
12149. Pacific Beach, San Diego.
28158. Pacific Beach.
28159. Small ravine at Pacific Beach.
28453. Silty beds in road bank on canyon road in southwest corner of Balboa Park, San Diego.
28454. Cut in strata at stairway to concession, Balboa Park, San Diego.
28644. Pacific Beach, San Diego.
28880. On Market Street, 1/10 mile east of Euclid Street, in Las Chollas Valley, San Diego. [= SD Loc. 408]
28882. Small canyon on south slope of Mt. Soledad.
28884. Embankment on Windsor Drive where Tourmaline Avenue would intersect if projected, Pacific Beach.
28885. Small ravine in west face of terrace 250 yards north of Mexican Boundary and 3/4 mile from the coast (a little north of south edge of willow patch and a farm road). [= SD Loc. 416; UCLA 310]
28886. 200 yards south of end of Law Street, if projected, Pacific Beach.
28887. *Dosinia* beds, 1/5 mile south of the Ford Building at bottom of Cabrillo Canyon, San Diego.
28888. Fossiliferous strata 10 to 20 feet above the road in the first terrace in prominent cut on west side of the road at the lower entrance to Mount

- Hope Cemetery, between Imperial Avenue and the old Cuyamaca railroad (= 36th Street). [= SD Loc. 409; UCLA Loc. 303]
28889. Fifth ravine north (about 1/4 mile) of the Mexican boundary, at west face of terrace 3/4 mile east of coast, the ravine debouching near the north end of a willow patch. [= SD Loc. 417]
28890. 0.4 mile north of Broadway on Fairmount Avenue, San Diego.
28891. West shore of Bay Point near Fontera and La Mancha streets, San Diego.
28892. 200 feet north of Mexican boundary and 3/4 mile east of coast, in east-west ravine, tributary to a larger south north ravine at right angle, in first terrace above Tiajuana River plain. [= UCLA Loc. 294; SD Loc. 331]
28893. Corner of India and Upas streets, San Diego.
28894. In canyon below ranch one half mile north up Aquamar Lane from Foothill Boulevard, Pacific Beach.
31320. Market Street extension at 54th Street, San Diego.
31356. Pacific Beach, San Diego.
33334. 100-foot bluff with fossiliferous concretions in clay quarry at end of Arroyo Drive, San Diego.
34221. Encinitas, San Diego County.
35025. Pacific Beach, San Diego.
36384. About two feet above top of basal conglomerate of San Diego Fm. in road cut on east side of Cabrillo Freeway at elevation of about 225 feet, nearly opposite Mercy Hospital, San Diego.
36599. Intersection of Wabash, Imperial and side street entering on arroyo about 1000 feet west of Lucky Lager warehouse, San Diego. Reworked fossils in whitish sand.

SAN DIEGO SOCIETY OF NATURAL HISTORY

2. Northeast side of gulch at elevation of 90 feet, 300 to 400 yards west of Rose Canyon, on south slope of Mt. Soledad.
4. Gulch no. 2, a little above its middle, at an elevation of about 140 feet, about 1/3 mile from Rose Canyon highway, south slope of Mt. Soledad. [= SD Loc. 80; CAS Loc. 1181]
5. Second gulch west of Rose Canyon highway, south slope of Mt. Soledad, 30 feet higher than Loc. 4 (SD).
10. Fossil Canyon, just north of Telegraph Canyon, about 1/2 mile east of Chula Vista.
17. About 3/8 mile up side canyon draining into long canyon, under the words "La Nacion" on U.S.G.S. topog. map of San Diego quad.
20. Approximately at point of intersection of 11th and Fir streets, if projected, along old road leading up south ridge of mesa from canyon bottom, Balboa Park, San Diego.
21. West end of Diamond Street, Pacific Beach. [= CAS Loc. 1178]
23. West side of hill just east of corner of Haines and Tourmaline streets, Pacific Beach.
24. About 150 feet south of Eocene-Pliocene contact, 3/4 miles north of Garnet Street Pier, Pacific Beach.
25. In bank at side of road just east and north below Mercy Hospital, on Sixth Street grade leading down into Mission Valley, San Diego.
27. Cliffs on east side of Reynard Way near mouth of canyon, 100 yards off main highway near old brickyard. [= CAS Loc. 1186]
29. On end of point between Cabrillo Canyon and a gulch about 100 m south of the west end of Laurel Street bridge across Cabrillo Canyon in Balboa Park. [= CAS Loc. 1402]
34. Northeast corner of India and Thorn streets, San Diego. [= CAS Loc. 1132 and 1419]
36. Columbia and State streets, San Diego.
37. Pacific Beach, unlocalized.
38. Northeast corner of India and Spruce streets, San Diego. [= CAS Loc. 1418]
54. India Street near Spruce Street, San Diego.
61. About 2 miles south of Ocean Beach and about 2/3 of a mile north of the military reservation, San Diego.
70. Balboa Park, San Diego.
75. Southeast corner of India and Upas streets, San Diego. [= CAS Loc. 1404]
79. Northeast corner of India and Spruce streets, San Diego. [= CAS Loc. 1418]
80. A little above middle part of a gulch 1/3 of a mile west of Rose Canyon, south slope of Mt. Soledad [= CAS Loc. 1181 and 1401]
81. Under bridge 1/2 mile east of Mission Cliffs Gardens, San Diego.
83. Reynard Way, San Diego.
88. South slope of Mt. Soledad.
150. Pacific Beach. [= CAS Loc. 1400]
302. San Diego, unlocalized.
331. Exposure in east-west ravine tributary to a larger south-north ravine at right angle, in first terrace above Tiajuana River plain, 200 feet north of Mexican boundary and 3/4 mile from the coast. [= CAS Loc. 28892]
365. Second ravine north of Rose Canyon, south slope of Mt. Soledad.
402. Lowest *Pecten healeyi* bed exposed just south of ravine which is just south of Eocene-Pliocene contact, Pacific Beach.
403. Including and above *Pecten healeyi* bed at Loc. 402 (SD), Pacific Beach.
404. *Pecten invalidus* bed at second ravine south of Eocene-Pliocene contact, Pacific Beach.

- 320A. In chalky-white marl-like sediment 11 feet thick, 110 feet back of house at Loc. 320 (LAM).
 323. Under bridge between Fifth Street and the Radio Station, about 160 feet from the fence and about 350 feet from the Radio Station, San Diego.
 1141. 32nd and Woolman Avenue, San Diego.
 1155. Between Reynard Way and Union Street, San Diego.
 1176. 0.3 mile north of San Diego well on road up

hill.

- A1323. Fossil Canyon east of Chula Vista.
 A2081. Pacific Beach.
 P87. Upas and India streets, San Diego.
 P87. No. 8325. 32nd Avenue and Woolman Street, San Diego.
 P87. No. S8339. Pacific Beach
 P87. No. S8443. Southwest of the end of the bridge over Cabrillo Canyon, Balboa Park, San Diego.
 P87. No. S8442. San Diego, unlocalized.

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294. 200 feet north of Mexican boundary in east-west ravine tributary to larger south-north ravine in first terrace above Tiajuana River plain, three fourths mile east from the coast. [= SD Loc. 331; CAS Loc. 28892]
 295. Second ravine west of mouth of Rose Canyon, south slope of Mt. Soledad. [= SD Loc. 365]
 296. Street cut on northwest side of Fairmount, 0.4 mile north of intersection with Broadway, San Diego.
 298. Pacific Beach, San Diego. [= SD Loc. 402]
 299. *Pecten healeyi* bed and above it, commencing at second ravine south of Pliocene-Eocene contact, Pacific Beach [= SD Loc. 404]
 300. Coarse sandstone containing *Chlamys invalida*, extending south from second ravine south of Pliocene-Eocene contact, Pacific Beach. [= SD Loc. 403]
 301. Hard coarse sandstone bed exposure beginning at third ravine south Eocene-Pliocene contact, tact, Pacific Beach.
 302. Road cut 0.1 mile east of Euclid Avenue on north side of Market Street, San Diego. [= SD Loc. 408; CAS Loc. 28880]
 303. Between Imperial Avenue and old Cuyamaca railroad (36th Street), San Diego. [= SD Loc. 409; CAS Loc. 28888]
 305. "Barnacle Reef" in coquina sandstone just below bottom of Sweitzer conglomerate, on spur of mesa across Las Chollas Valley.
 306. Float at base of railroad cut between Las Chollas Valley and 32nd and Greeley streets, San Diego. [= SD Loc. 412]
 307. About a block above Market Street Bridge, Las Chollas Valley, San Diego. [= SD Loc. 413]
 309. Stratum with oysters in building excavation at southeast corner of India and Upas streets, San Diego. [= SD Loc. 415]
 310. In small ravine facing west (a little north of south edge of willow patch and a farm road)

in west face of terrace, 250 yards north of Mexican boundary and 3/4 mile east of coast. [= CAS Loc. 28885; SD Loc. 416]

311. San Diego, unlocalized.
 312. Second ravine north of Loc. 294, fifth ravine north (about 1/4 mile) of the Mexican boundary, at west face of terrace 3/4 mile east of the coast, the ravine debouching near the north end of a willow patch. [= SD Loc. 417; CAS Loc. 28889]
 331. San Diego, unlocalized.
 1382. *Pecten bellus* beds in cut bank behind a leveling excavation back from 11th Street (eastward) and south of a dirt road across from cobblestone bridge.
 1383. *Macoma* beds 20 feet stratigraphically above the *Pecten bellus* beds and just below the terrace gravels in cut bank behind a leveling excavation back from 11th Street (eastward) and south of a dirt road across from the cobblestone bridge, San Diego.
 1384. *Pecten healeyi* beds in road cut north of fork in road up ravine, opposite a grove of fir trees and between latitude of Date and Elm streets, San Diego.
 1385. *Pecten healeyi* beds in cut bank 1268 to 1410 feet along fork in road emerging just east of Federal Building in Balboa Park Plaza, 10 to 12 feet stratigraphically below *Dosinia* beds at Loc. 1386 (SD).
 1386. *Dosinia* beds in cut bank 338 feet along ravine road from Loc. 1385 and just below the southeast corner of the Federal Building in Balboa Park, San Diego.
 2359. Soft brown fine-grained sandstone outcropping in a small canyon parallel to and about two-tenths of a mile west of the mouth of Rose Canyon and four tenths mile north of Garnet Avenue (2.6 mile S. 40° E. of triangulation station on Mount Soledad).
 2420. Soft Pliocene sands exposed in bluffs along Pacific Beach, about 1/2 mile southeast of False Point, La Jolla quad.

408. Road cut 0.1 mile east of Euclid Avenue on north side of Market Street, San Diego. [= CAS 28880]
409. First prominent cut on west side of road, lower entrance to Mt. Hope Cemetery, between Imperial Avenue and old Cuyamaca railroad (36th Street), San Diego. [= CAS Loc. 28888; UCLA Loc. 303]
412. Between Las Chollas Valley and 32nd and Greeley streets, San Diego. [= UCLA Loc. 412]
413. Large concretionary lenses following bedding of outcrop prominent in bottom of wash, about a block above Market Street Bridge, Las Chollas Valley, San Diego.
415. Oyster layer in building excavation at southeast corner of India and Upas streets, San Diego. [= UCLA Loc. 309]
416. In west face of terrace, 250 yards north of Mexican Boundary, 3/4 mile east of coast. [= CAS Loc. 28885; UCLA 310]
417. Second ravine north of Loc. 331 (SD) and fifth ravine north of Mexican boundary (about 1/4 mile), in west face of terrace about 3/4 mile from the coast. This ravine debouches near the north end of a patch of willows. [= CAS Loc. 28889]
446. Pacific Beach, unlocalized.
1142. Near Fir and Boundary streets, San Diego.
2359. San Diego, unlocalized.
2407. Pacific Beach.
2912. Reynard Way, San Diego.
2915. India Street near Spruce Street, San Diego.
2916. Reynard Way, San Diego.
2930. Reynard Way (formerly known as "Brickyard Canyon"), about 1/4 mile northeast of the old brickyard, in a small gulch southeast of the street.
2931. Reynard Way, San Diego.
2939. Same as Loc. 2930.
2946. Same as Loc. 2930.
2948. Same as Loc. 2930.
2949. Same as Loc. 2930.
2951. Reynard Way, San Diego.
2954. Reynard Way, San Diego.
3203. Kensington Park, San Diego.
3206. Kensington Park, San Diego.
3209. Kensington Park, San Diego.
3592. Reynard Way, San Diego.
4413. Juniper and Boundary Streets, San Diego.
4735. India Street near Spruce Street, San Diego.
5001. Soledad Mountain, San Diego.
5003. Soledad Mountain, San Diego.
5006. Soledad Mountain, San Diego.
5251. Balboa Park, San Diego.
5252. Cabrillo Canyon, Balboa Park.
5679. Las Chollas Valley, San Diego.
6304. Pacific Beach, San Diego.
6307. Pacific Beach, unlocalized.
6386. Pacific Beach, San Diego.
6387. Pacific Beach, San Diego.
6389. Pacific Beach, San Diego.

LOS ANGELES COUNTY MUSEUM

103. West side of Reynard Way, between Curlew and Eagle streets, San Diego.
104. West side of Reynard Way, between Curlew and Eagle streets, San Diego.
107. 100-foot bluff with scattered fossiliferous concretions in clay quarry at end of Arroyo Drive, San Diego. [= CAS Loc. 33334]
116. Oyster bed at corner of Dove and Maple streets, San Diego.
121. On south side of the junction of Washington Street and University Avenue "Douglas Freeway," continuation of Andrews Place, San Diego.
122. 20 to 30 feet below the end of Loring Street, Pacific Beach.
124. West side of Reynard Way, between Curlew and Eagle streets, San Diego.
127. Shell stratum on Wabash Freeway, Market Street continuation, 1/4 mile south of Euclid Street, Encanto.
180. 2200 block on east side of La Jolla Boulevard at the intersection with Tiras Street, San Diego.
302. Twenty feet of sand and silt above street level across the street from the house at 2840 Columbia Street, San Diego.
- 302A. In chalky-white marl-like sediment 11 feet thick, 110 feet behind the house at 835 South 32nd Street, San Diego.
305. 2400 feet east and 1350 feet south of northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S.G.S. topog. map, San Ysidro quad., ed. 1943).
- 305A. West side of next gully east of Loc. 305 (LAM) at the same elevation: fossils in float slump and consolidated boulders, silt and sandstone, and silt in place.
- 305B. A small pocket in gully next to 305A (LAM).
- 305C. Exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (U.S.G.S. topog. map, San Ysidro quad., rev. 1953).
308. 0.23 mile north of intersection Harbor Boulevard and Tourmaline Street, Pacific Beach.
309. Two canyons east of Kate Sessions School, approximately 0.3 mile west of Balboa Avenue from U. S. 101, turning on to a paved road passing in front of a pink building, San Diego.
318. Just above the gates and cow shed, 200 feet from the road and 30 feet above the valley floor, on Knox Ranch hill.
319. Exactly between United States-Mexico boundary fence and Mr. Ericson's (the manager's) house, 27 feet above the road level on the shoulder of the second hill.
320. 100 feet back of house No. 835, South 32nd Street, San Diego.

SAN DIEGO STATE COLLEGE

31. Same as Loc. 305A (LAM).
32. South side of Tiajuana River near mouth of Valley; sandstone-siltstone at base of hill south of Monument Road and east of Border Naval Reservation, east side of mouth of a prominent gully west of Goat Canyon, southeast 1/4 Sec. 8, T. 19 S., R. 2 W. (see U.S.G.S. topog. map, San Ysidro quad., ed. 1953). [= LAM Loc. 305A]
47. About six feet stratigraphically above friable sandstone exposed at bottom of gully at Loc. 46 (= 47) which is, south side of Tiajuana River valley; sandstone-siltstone at base of hill south of Monument Road and east of Border Naval Reservation, east side of prominent gully west of Goat Canyon,

southeast 1/4 of Sec. 8, T. 19 S., R. 2 W, San Bernardino Base and Meridian (see U.S.G.S. topog. map, San Ysidro quad., ed. 1953). [= LAM Loc. 305C]

222. South side of Mt. Soledad; shell bed at base of cut in bank.
223. South side of Mt. Soledad; shell bed at base of cut in bank and about five feet stratigraphically lower than at Loc. 222 (SDSC).

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- A-8333. Same as Loc. 305 (LAM).

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A

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- Fig. 1. *Nucula (Ennucula) balboana* n. sp. Holotype (California Academy of Sciences), from Loc. 12099 (CAS), San Diego well, Balboa Park, San Diego, Calif. Length 13.4 mm.; height 10.7 mm.; convexity (both valves together) 7.2 mm. View of the exterior of the left valve. P. 145
- Fig. 2. *Nucula (Ennucula) balboana* n. sp. Holotype. View of the exterior of the right valve. P. 145
- Fig. 3. *Nucula (Ennucula) balboana* n. sp. Paratype (California Academy of Sciences), from same locality as the holotype shown in fig. 1. Length 11.4 mm. View showing hinge of a left valve. P. 145
- Fig. 4. *Nucula (Ennucula) balboana* n. sp. Holotype. Dorsal view of specimen shown in figs. 1 and 2. P. 145
- Fig. 5. *Nucula (Lamellinucula) exigua* Sowerby. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), second ravine north of Loc. 294 (UCLA), fifth ravine north (about ¼ mile) of the Mexican boundary, at west face of a terrace, ¾ mile east of the coast. Length 4.6 mm.; height 4.8 mm. View of exterior of a right valve. P. 146
- Fig. 6. *Nucula (Lamellinucula) exigua* Sowerby. View of the interior of the valve shown in fig. 5.
- Fig. 7. *Acila (Truncacila) castrensis* Hinds. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co., Calif. (see U.S. Geol. Surv. topog. map, San Ysidro quad., ed. 1943). Length 9.5 mm.; height 9.2 mm. View of the exterior of a left valve. P. 147
- Fig. 8. *Acila (Truncacila) castrensis* Hinds. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 10.1 mm.; height 8.2 mm. View of the exterior of a right valve.
- Fig. 9. *Acila (Truncacila) castrensis* Hinds. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 9.8 mm.; height 8.2 mm. View of the exterior of a left valve.
- Fig. 10. *Acila (Truncacila) castrensis* Hinds. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 9.0 mm.; height 8.0 mm. View of the exterior of a right valve.
- Fig. 11. *Nuculana (Saccella) taphria* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 19.3 mm.; height 12.9 mm. View of the exterior of a right valve which is very high in proportion to the length. P. 150
- Fig. 12. *Nuculana (Saccella) taphria* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 16.4 mm.; height 9.6 mm. View of the exterior of a right valve.
- Fig. 13. *Nuculana (Saccella) taphria* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 13.7 mm.; height 8.4 mm.
- Fig. 14. *Glycymeris (Axinola) grewingki* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 25.1 mm.; height 26.2 mm. View of the exterior of a left valve. P. 159
- Fig. 15. *Glycymeris (Axinola) profunda* Dall. Paratype (No. 696, California Academy of Sciences), from Pacific Beach, San Diego, Calif. Length 23 mm.; height 23.4 mm. View of the exterior of a left valve from the original lot of this species collected by Henry Hemphill.
- Fig. 16. *Nuculana (Saccella) taphria* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 18.5 mm.; height 10.3 mm. View of the exterior of a left valve.
- Fig. 17. *Nuculana (Saccella) taphria* Dall. View of the interior of the specimen shown in fig. 16.
- Fig. 18. *Nuculana (Saccella) taphria* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 21 mm.; height 12.3 mm.
- Fig. 19. *Glycymeris (Axinola) grewingki* Dall. View of the interior of the specimen shown in fig. 14.
- Fig. 20. *Glycymeris (Axinola) profunda* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 26.4 mm.; height 26.5 mm. View of the exterior of a left valve.
- Fig. 21. *Glycymeris (Axinola) profunda* Dall. View of the interior of the specimen shown in fig. 20.
- Fig. 22. *Glycymeris (Axinola) profunda* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 21.2 mm.; height 20 mm. View of the interior of a left valve.
- Fig. 23. *Glycymeris (Axinola) profunda* Dall. View of the interior of the specimen shown in fig. 15.
- Fig. 24. *Glycymeris (Axinola) grewingki* Dall. View of the exterior of the specimen shown in fig. 22.
- Fig. 25. *Glycymeris (Axinola) profunda* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 23.2 mm.; height 25.3 mm. View of the exterior of a left valve.
- Fig. 26. *Arca (Arca) sisquocensis* Reinhart. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length (incomplete) 11.2 mm.; height (incomplete) 5.5 mm. View of exterior of the upper portion of a right valve. This specimen virtually disintegrated during the process of photography.
- Fig. 27. *Arca (Arca) sisquocensis* Reinhart. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 23.8 mm.; height 16.4 mm. View of the exterior of an incomplete right valve. The specimen, very fragile, partially disintegrated during preparation of a photograph.
- Fig. 28. *Glycymeris (Axinola) profunda* Dall. Paratype (No. 696b, California Academy of Sciences), from Pacific Beach, San Diego, Calif. Length 20.8 mm.; height 21.8 mm. View of the exterior of a right valve from the type lot of this species collected by Henry Hemphill.
- Fig. 29. *Glycymeris (Axinola) profunda* Dall. View of the interior of the specimen shown in fig. 28.
- Fig. 30. *Glycymeris (Axinola) profunda* Dall. Hypotype (San Diego Society of Natural History), from Loc. 150 (SD), upper portion of the section of Pliocene strata at Pacific Beach, San Diego, Calif. View of the hinge of the specimen shown in fig. 37, which is 32.8 mm. long (incomplete) and 35 mm. high.
- Fig. 31. *Arca (Arca) sisquocensis* Reinhart. Enlarged view of hinge and ligamental area of the specimen shown in fig. 27.
- Fig. 32. *Arca (Arca) sisquocensis* Reinhart. View of the interior of the specimen shown in fig. 26.
- Fig. 33. *Arca (Arca) sisquocensis* Reinhart. View of the exterior of the specimen shown in figs. 27 and 31.
- Fig. 34. *Glycymeris (Axinola) profunda* Dall. View of the interior of the specimen shown in fig. 25.
- Fig. 35. *Barbatia (Fugleria) illota* Sowerby. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 18.3 mm.; height 13.3 mm. View of the exterior of a right valve. P. 157
- Fig. 36. *Barbatia (Fugleria) illota* Sowerby. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 17.5 mm.; height 13 mm. View of the exterior of a left valve.
- Fig. 37. *Glycymeris (Axinola) profunda* Dall. View of the exterior of the same specimen shown in fig. 30.
- Fig. 38. *Barbatia (Fugleria) illota* Sowerby. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length (anterior end incomplete) 20.1 mm.; height 14.3 mm. View of the interior of a right valve.
- Fig. 39. *Barbatia (Fugleria) illota* Sowerby. View of the exterior of the specimen shown in fig. 38.
- Fig. 40. *Barbatia (Fugleria) illota* Sowerby. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 15.4 mm.; height 10.5 mm. View of the interior of a left valve. The lack of teeth in the central portion of the hinge is shown clearly in figures 38 and 40.

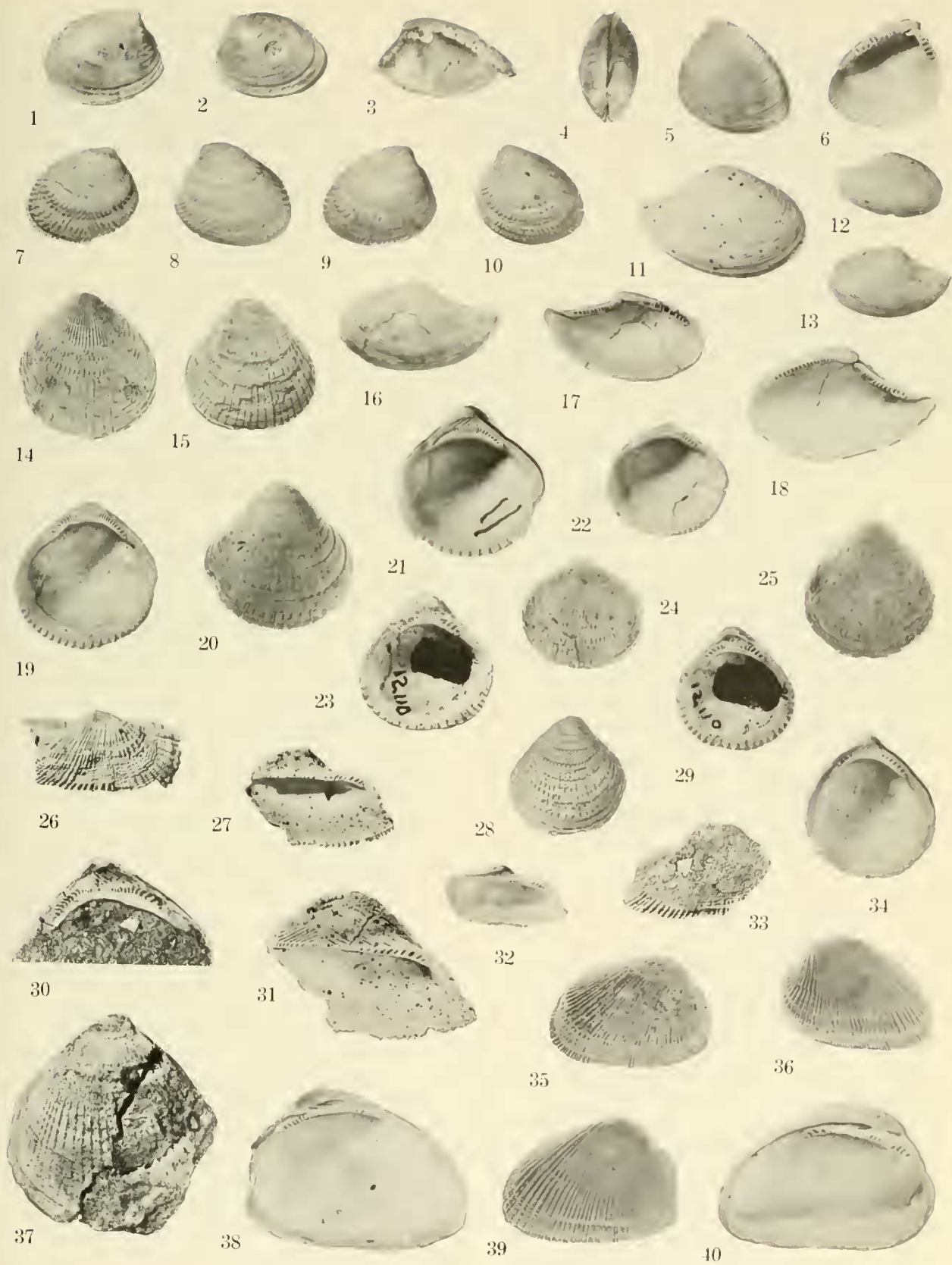
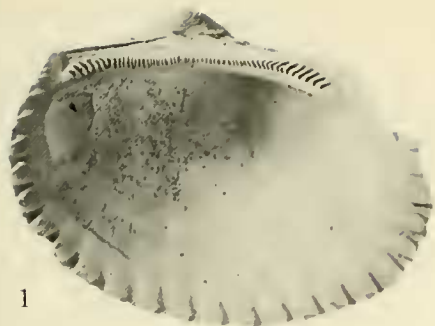


PLATE 28

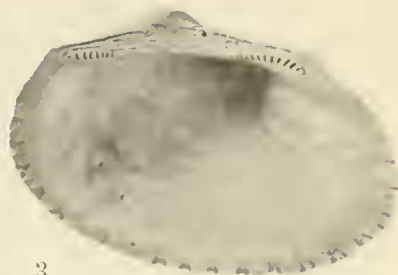
- Fig. 1. *Anadara trilineata* Conrad. Hypotype (Los Angeles County Museum), from Loc. 305, 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co., Calif. (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 67.1 mm.; height 51 mm. View of the interior of a right valve. P. 154
- Fig. 2. *Anadara trilineata* Conrad. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), second ravine north of Loc. 294 (UCLA), fifth ravine north (about $\frac{1}{4}$ mile) of the Mexican boundary, at west face of a terrace $\frac{3}{4}$ mile east of the coast. Length 31 mm.; height 21 mm.; convexity (both valves together) 16 mm. View of dorsal area showing the sharply pointed anterior margin when viewed from above. P. 154
- Fig. 3. *Anadara trilineata* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 62 mm.; height 42 mm. View of the interior of a right valve.
- Fig. 4. *Anadara trilineata* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 52 mm.; height 40 mm. View of the exterior of a right valve.
- Fig. 5. *Anadara trilineata calcarea* Grant and Gale. Hypotype (California Academy of Sciences), from the San Diego Well, Balboa Park, San Diego. Length 74 mm.; height 69 mm.; convexity (both valves together) 46.6 mm. View of dorsal area showing rounded anterior end when viewed from above. P. 156
- Fig. 6. *Anadara trilineata* Conrad. View of the exterior of the specimen shown in fig. 3.
- Fig. 7. *Anadara trilineata calcarea* Grant and Gale. View of the interior of the right valve of the specimen shown in fig. 5.
- Fig. 8. *Anadara trilineata calcarea* Grant and Gale. View of the interior of the left valve of the specimen shown in fig. 5.
- Fig. 9. *Anadara trilineata calcarea* Grant and Gale. View of the exterior of the valve shown in fig. 8.
- Fig. 10. *Anadara trilineata calcarea* Grant and Gale. View of the exterior of the valve shown in fig. 7.



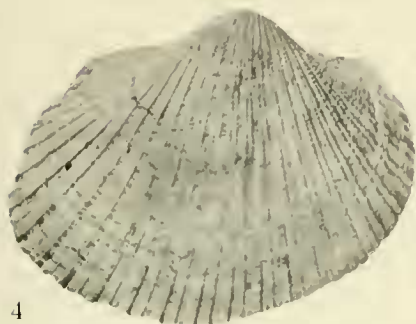
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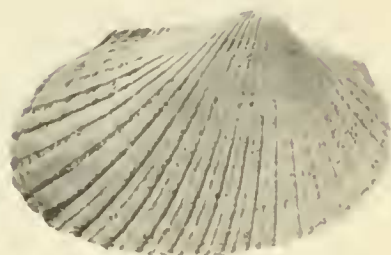
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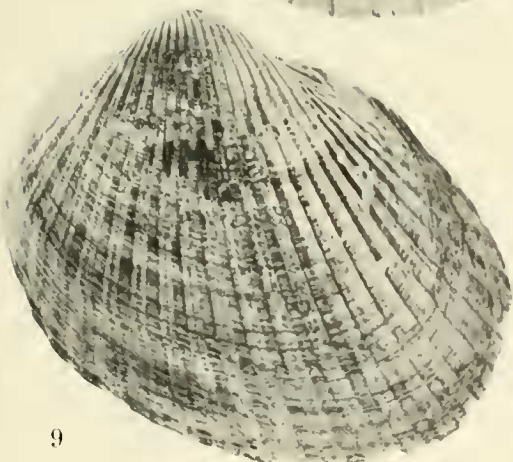
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PLATE 29

- Fig. 1. *Pecten (Oppenheimopecten) vogdesi* Arnold. Hypotype (Los Angeles County Museum), from Loc. 320A (LAM), chalky white sediment in exposure 100 feet behind the house at 835 South 32nd Street, San Diego. Length 105 mm.; height 84.4 mm. View of the exterior of a left valve. P. 181
- Fig. 2. *Pecten (Flabellipecten) stearnsii* Dall. Paratype (No. 525a, California Academy of Sciences), from Pacific Beach. Length 90.6 mm.; height 78 mm. View of the exterior of a right valve. This specimen is one of the original lot (H. Hemphill, No. 12138) of *Pecten stearnsii*. P. 178
- Fig. 3. *Pecten (Oppenheimopecten) vogdesi* Arnold. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 111 mm.; height 106.5 mm. View of the exterior of a right valve. P. 181
- Fig. 4. *Pecten (Flabellipecten) stearnsii* Dall. Left valve of the specimen shown in fig. 2.
- Fig. 5. *Pecten (Oppenheimopecten) vogdesi* Arnold. Hypotype (Stanford University), from 31st and Logan Avenue, San Diego. Length 94.6 mm.; height (incomplete), 91.4 mm. View of the exterior of a right valve, the umbonal portion lacking. P. 181
- Fig. 6. *Pecten (Oppenheimopecten) vogdesi* Arnold. View of the interior of the specimen shown in fig. 1.

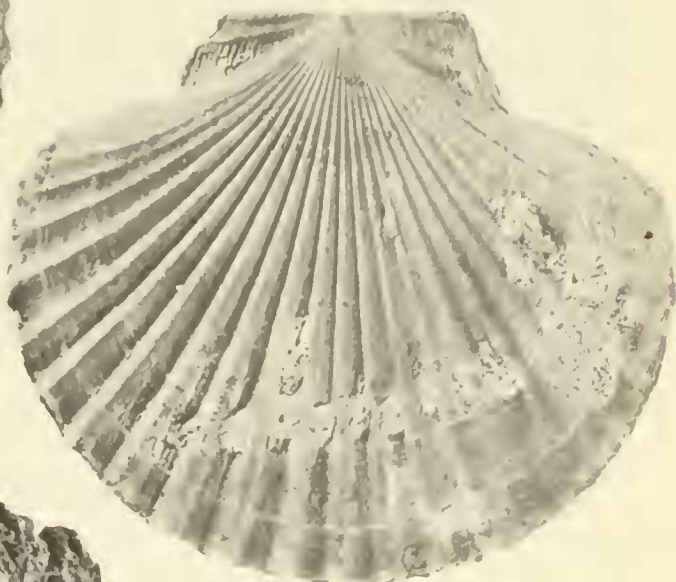


PLATE 30

- Fig. 1. *Pecten (Pecten) bellus* Conrad. Hypotype (California Academy of Sciences), from Pacific Beach. Length 70.4 mm.; height 67.3 mm. View of the exterior of a right valve. This is paratype No. 526b (H. Hemphill No. 12139) from the original lot of *Pecten hemphillii* Dall. P. 174
- Fig. 2. *Pecten (Pecten) bellus* Conrad. Hypotype (California Academy of Sciences), from Pacific Beach. Length 72.5 mm.; height 64 mm. This is paratype No. 526 (H. Hemphill No. 12139) from the original lot of *Pecten hemphillii* Dall.
- Fig. 3. *Pecten (Pecten) bellus* Conrad. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 26.6 mm.; height 24.3 mm. View of the exterior of a right valve. P. 174
- Fig. 4. *Pecten (Pecten) bellus* Conrad. Hypotype (California Academy of Sciences), from Pacific Beach. Length 87.3 mm.; height 78.8 mm. This is paratype No. 526a (H. Hemphill No. 12139) from the original lot of *Pecten hemphillii* Dall. Note the broad ribs on this specimen in comparison with those on the specimen shown in fig. 1. P. 174
- Fig. 5. *Chlamys (Chlamys) opuntia* Dall. Hypotype (California Academy of Sciences), from Loc. 1183 (CAS), on Eagle Street just north of Quince Street, just east of Reynard Way, San Diego. Length 34.8 mm.; height 37 mm. View of the exterior of a right valve. P. 192
- Fig. 6. *Chlamys (Chlamys) opuntia* Dall. Hypotype (Los Angeles County Museum), from Loc. 107 (LAM), clay quarry at end of Arroyo Drive, San Diego. Length 38.4 mm.; height 43.5 mm.
- Fig. 7. *Chlamys (Argopecten) subdola* Hertlein. Hypotype (California Academy of Sciences), from Loc. 1413 (CAS), lower beds in section of Pliocene strata exposed at Pacific Beach. Length 45.5 mm.; height 45 mm. View of the exterior of a right valve. P. 201
- Fig. 8. *Chlamys (Argopecten) subdola* Hertlein. View of the exterior of the left valve of the specimen shown in fig. 7.
- Fig. 9. *Pecten (Pecten) bellus* Conrad. Hypotype (California Academy of Sciences), from Pacific Beach. View of the exterior of the left valve of the specimen shown in fig. 4. This is the exterior of the valve shown on plate 32, fig. 14.
- Fig. 10. *Chlamys (Chlamys) jordani* Arnold. Hypotype (California Academy of Sciences), from Loc. 28893 (CAS), corner of India and Upas streets, San Diego. Length 13.8 mm.; height 26.2 mm. View of the exterior of a left valve of a juvenile specimen.

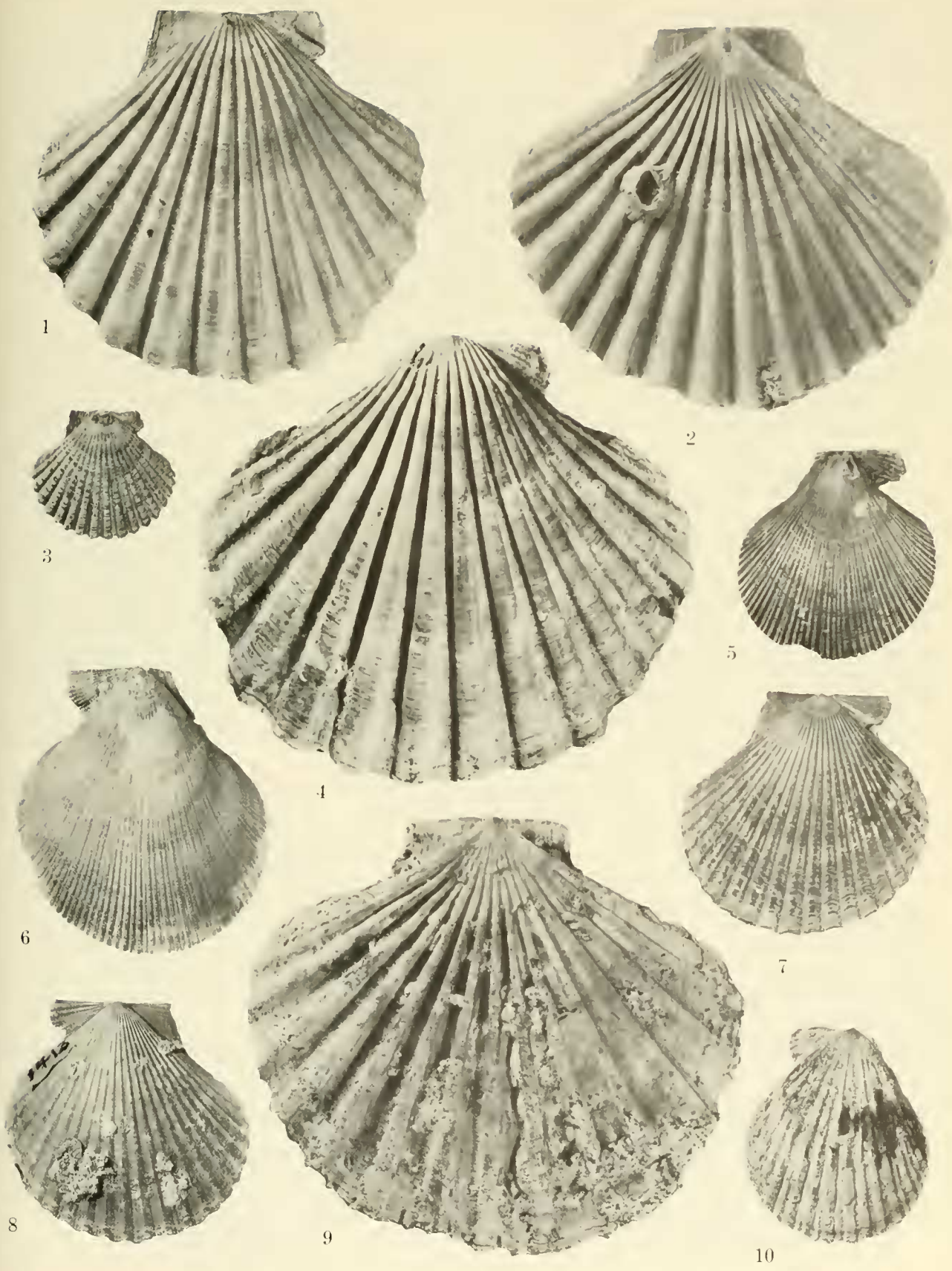
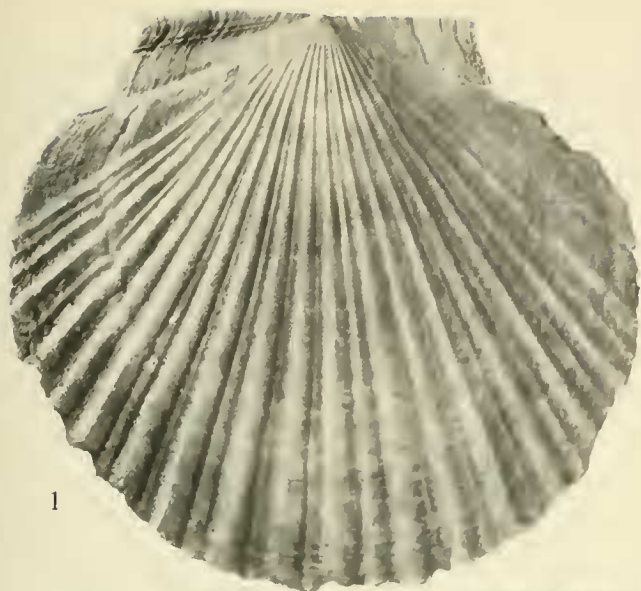


PLATE 31

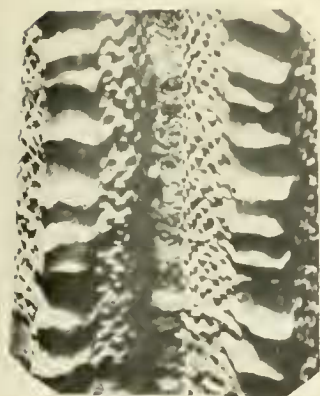
- Fig. 1. *Pecten (Patinopecten) healeyi* Arnold. Hypotype (San Diego Society of Natural History), from Loc. 365 (SD), second ravine west of mouth of Rose Canyon, south slope of Mount Soledad. Length 139 mm.; height 130 mm. View of the exterior of a left valve. P. 183
- Fig. 2. *Chlamys (Chlamys) hastata ellisi* n. subsp. Holotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 66 mm.; height 68.5 mm. View of the exterior of a right valve. P. 190
- Fig. 3. *Chlamys (Chlamys) hastata ellisi* n. subsp. Enlargement of a portion of the specimen illustrated in fig. 2, showing the honeycomb-like sculpture covering the valve. P. 190
- Fig. 4. *Pecten (Patinopecten) healeyi* Arnold. Paratype from the original lot of *Pecten expansus* Dall (No. 527, California Academy of Sciences), from San Diego. Length 155 mm.; height 146 mm. View of the exterior of a left valve.
- Fig. 5. *Chlamys (Swiftopecten) parmelvei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 2. Length 31.9 mm.; height 36.8 mm. View of the exterior of a small right valve. P. 206
- Fig. 6. *Pecten (Patinopecten) healeyi* Arnold. View of the exterior of right valve of specimen shown in fig. 4. P. 183
- Fig. 7. *Pecten (Patinopecten) healeyi* Arnold. Hypotype (San Diego Society of Natural History), from Loc. 37 (SD), Pacific Beach. Length 176 mm.; height 165 mm. View of the exterior of a right valve (ends of hinge imperfect), showing radial ribs some of which bear two, some three and occasionally four radial grooves. P. 183



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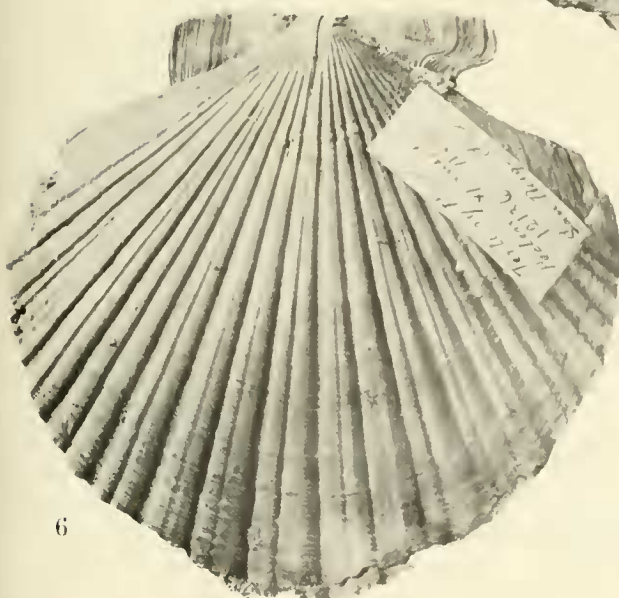
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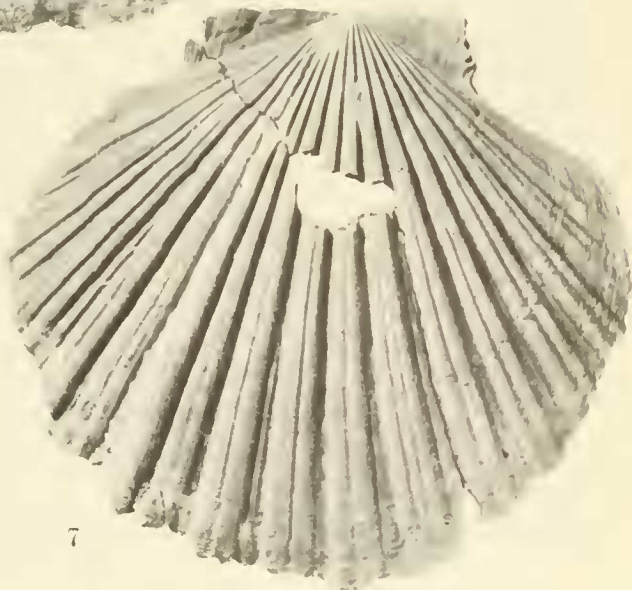
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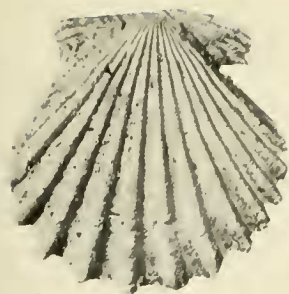
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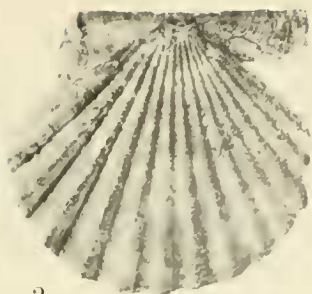
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PLATE 32

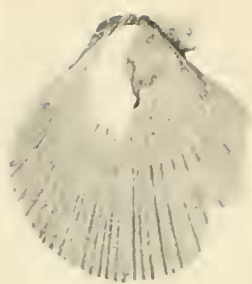
- Fig. 1. *Chlamys (Leptopecten) bellilamellata* Arnold. Hypotype (California Academy of Sciences), from Loc. 1400 (CAS), in upper portion of section of Pliocene strata at Pacific Beach, San Diego. Length 16 mm.; height 16.5 mm. View of the exterior of a right valve. P. 203
- Fig. 2. *Chlamys (Leptopecten) bellilamellata* Arnold. Hypotype (San Diego Society of Natural History), Loc. 331 (SD), exposure back of house No. 3550 on Dove Street, San Diego. Length 14.7 mm.; height 13.8 mm. View of the exterior of a right valve. P. 203
- Fig. 3. *Chlamys (Chlamys) cf. C. (C.) jordani* Arnold. Hypotype (California Academy of Sciences), from Loc. 28893 (CAS), corner of India and Upas streets, San Diego. Length (anterior side imperfect) 28 mm.; height 31 mm. View of the exterior of a right valve with unusually fine ribbing. P. 191
- Fig. 4. *Chlamys (Argopecten) circularis* Sowerby. Hypotype (California Academy of Sciences), from Loc. 1137 (CAS), 31st Street and Logan Avenue, San Diego. Length 28.5 mm.; height 28.6 mm.
- Fig. 5. *Chlamys (Chlamys) jordani* Arnold. Hypotype (California Academy of Sciences), from the same locality as the specimen shown in fig. 3. Length 15.6 mm.; height 17.5 mm. P. 191
- Fig. 6. *Chlamys (Chlamys) jordani* Arnold. View of the left valve of the specimen shown in fig. 5. P. 191
- Fig. 7. *Chlamys (Argopecten) ericellus* Hertlein. Holotype (No. 2998, California Academy of Sciences), from Loc. 1132 (CAS), Pacific Beach, San Diego. Length 29.1 mm.; height 28 mm. View of the exterior of a right valve. P. 199
- Fig. 8. *Chlamys (Leptopecten) bellilamellata* Arnold. Hypotype (California Academy of Sciences), from Loc. 105 (CAS), Pacific Beach, San Diego. Length 12.8 mm.; height 12.9 mm. View of the exterior of a left valve. P. 203
- Fig. 9. *Chlamys (Argopecten) collida* Hertlein. Hypotype (California Academy of Sciences), from Loc. 1413 (CAS), from lower portion of the section of Pliocene strata at Pacific Beach. Length 55.4 mm.; height 53.6 mm. View of the exterior of a left valve. P. 198
- Fig. 10. *Chlamys (Argopecten) jordani* Arnold. Hypotype (Los Angeles County Museum), from Loc. 107 (LAM), clay quarry at end of Arroyo Drive, San Diego. Length 45.7 mm.; height 47 mm. View of exterior of a right valve, the ears lacking. P. 191
- Fig. 11. *Chlamys (Argopecten) collida* Hertlein. Hypotype (Los Angeles County Museum), from Loc. 122 (LAM), Pacific Beach. Length 50 mm.; height 48.4 mm. View of the exterior of a right valve. P. 198
- Fig. 12. *Chlamys (Argopecten) jordani* Arnold. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 10. Length 32.2 mm.; height 34 mm. P. 191
- Fig. 13. *Chlamys (Argopecten) jordani* Arnold. Hypotype (California Academy of Sciences), from Loc. 1132 (CAS), Pacific Beach. Length 23.6 mm.; height 27.3 mm. View of the exterior of a left valve. P. 191
- Fig. 14. *Pecten (Pecten) bellus* Conrad. Paratype of *Pecten hemphillii* Dall, (No. 526a, California Academy of Sciences), from Pacific Beach. Length 87.3 mm.; height 77 mm. View of the interior of a specimen (H. Hemphill No. 12139) from the original lot of *Pecten hemphillii* Dall
- Fig. 15. *Chlamys (Argopecten) circularis* Sowerby. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1913). Length 24.6 mm.; height 25.2 mm. View of the exterior of a left valve. P. 197
- Fig. 16. *Chlamys (Argopecten) circularis* Sowerby. Hypotype (California Academy of Sciences), from the same locality as the specimen shown in fig. 15. Length 24.6 mm.; height 25.2 mm. View of the exterior of a right valve.



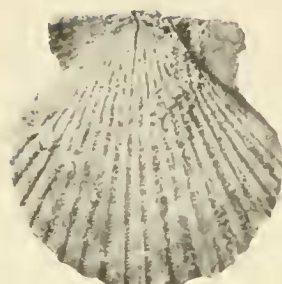
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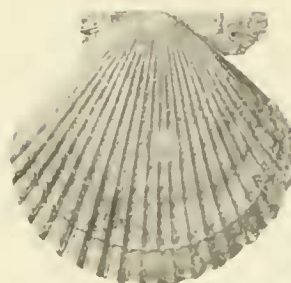
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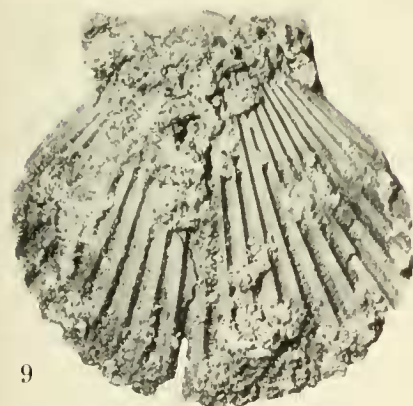
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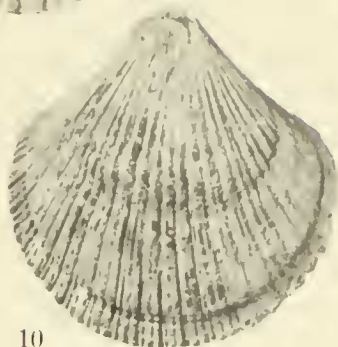
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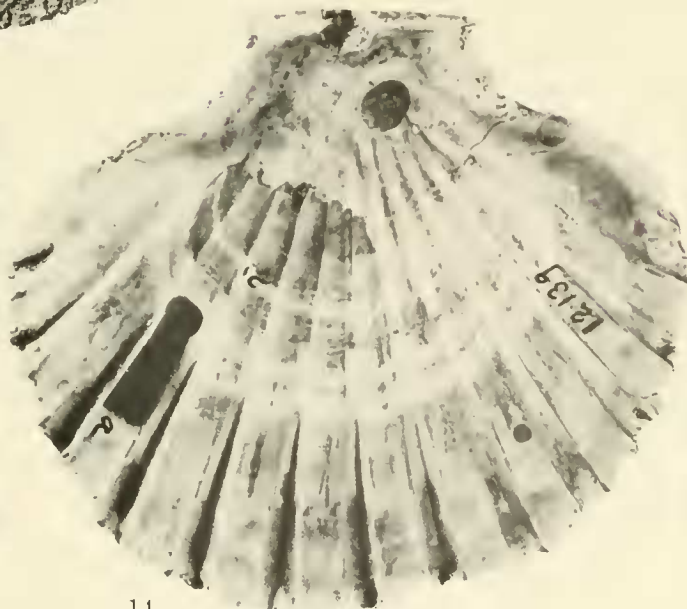
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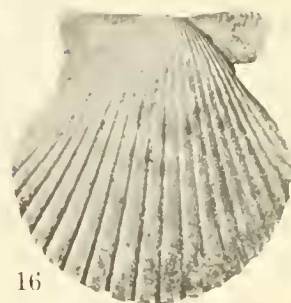
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PLATE 33

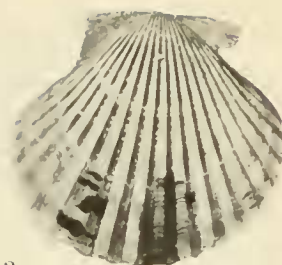
- Fig. 1. *Chlamys (Argopecten) invalida* Hanna. Hypotype (California Academy of Sciences), from Loc. 105 (CAS), Pacific Beach. Length 48 mm.; height 46.4 mm. View of the exterior of a right valve. P. 200
- Fig. 2. *Chlamys (Chlamys) hastata hercynus* Gould. Hypotype (California Academy of Sciences), from Loc. 2028 (CAS), Pacific Beach. Length 54 mm.; height 58 mm. View of the exterior of a right valve.
- Fig. 3. *Chlamys (Argopecten) invalida* Hanna. Hypotype (California Academy of Sciences), from Loc. 1179 (CAS), lower portion of the Pliocene section exposed at Pacific Beach. Length 35.5 mm.; height 33.3 mm. View of the exterior of a right valve. P. 200
- Fig. 4. *Chlamys (Chlamys) hastata* Sowerby. Hypotype (California Academy of Sciences), from Loc. 1132 (CAS), Pacific Beach. Length 54 mm.; height 61 mm. View of the exterior of a left valve. P. 188
- Fig. 5. *Chlamys (Chlamys) hastata* Sowerby. Hypotype (California Academy of Sciences), from the same locality as the specimen shown in fig. 2. Length 43 mm.; height 48.6 mm. View of the exterior of a right valve. P. 188
- Fig. 6. *Chlamys (Chlamys) hastata* Sowerby. View of the right valve of the specimen shown in fig. 4.
- Fig. 7. *Cyclopecten (Cyclopecten) pernomus* Hertlein. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM) at the same elevation. Length 4.2 mm.; height 1.2 mm. View of the exterior of a left valve. P. 213
- Fig. 8. *Chlamys (Argopecten) invalida* Hanna. Hypotype (California Academy of Sciences), from Loc. 1399 (CAS), in bluffs 100 to 200 yards south of the Eocene-Pliocene contact at Pacific Beach. Length 35.4 mm.; height 33.4 mm. View of the exterior of a left valve. P. 200
- Fig. 9. *Pecten (Patinopecten) bealeyi* Arnold. Hypotype (California Academy of Sciences), from Loc. 1400 (CAS), upper strata in Pliocene section at Pacific Beach. Length 26.6 mm.; height 27.6 mm. View of the exterior of a juvenile right valve. Traces of vaguely defined radial ribs are present along the ventral margin. The interior lacks any trace of ribs. P. 183
- Fig. 10. *Chlamys (Argopecten) hakei* Hertlein. Hypotype (San Diego Society of Natural History), from Juniper and Boundary streets, San Diego. Length 160 mm.; height 143 mm. View of the exterior of a left valve. P. 199
- Fig. 11. *Cyclopecten (Cyclopecten) pernomus* Hertlein. Hypotype (Los Angeles County Museum), from same locality as the specimen shown in fig. 7. Length 4.2 mm.; height 1.7 mm. View of the interior of a left valve. P. 213



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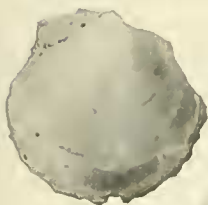
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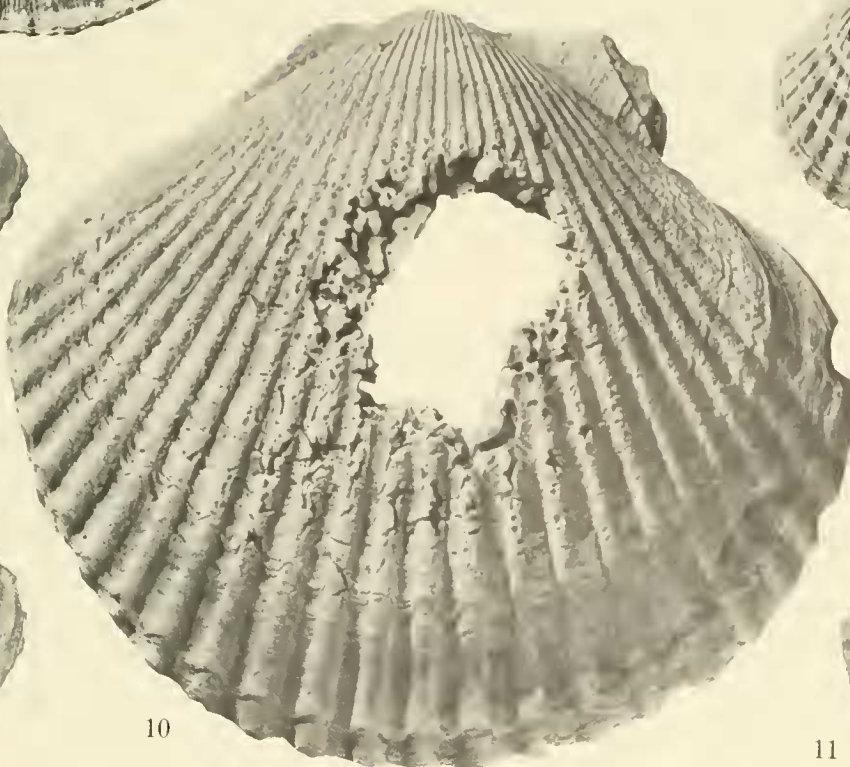
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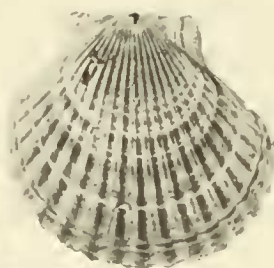
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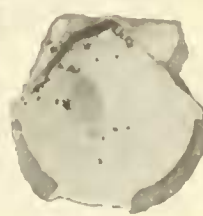
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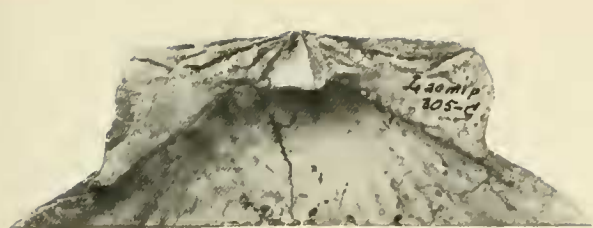
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PLATE 34

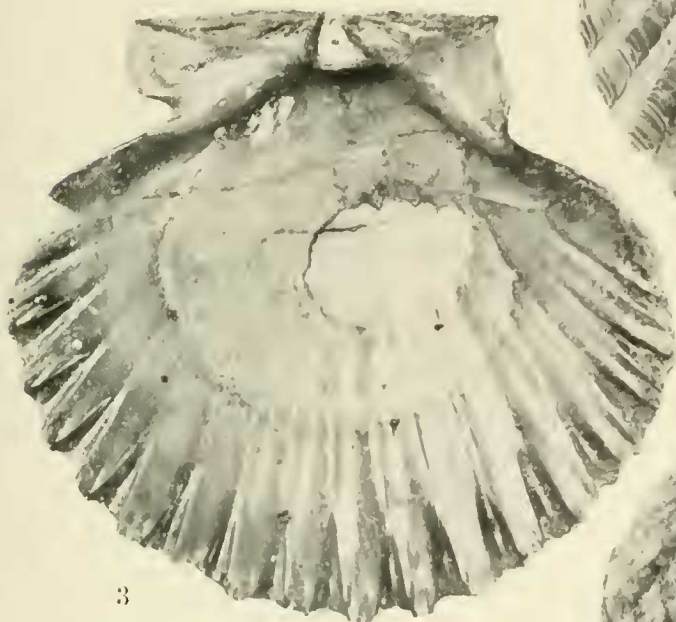
- Fig. 1. *Chlamys (Lyropecten) cerrosensis* Gabb. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length of hinge line 86 mm. View of the hinge of a left valve showing the well developed crura. P. 209
- Fig. 2. *Chlamys (Lyropecten) cerrosensis* Gabb. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 147 mm.; height 138 mm. View of the exterior of a right valve. P. 209
- Fig. 3. *Chlamys (Lyropecten) cerrosensis* Gabb. View of the interior of the valve shown in fig. 2.
- Fig. 4. *Chlamys (Lyropecten) cerrosensis* Gabb. View of the exterior of the valve shown in fig. 1. Length 156 mm.; height 142 mm.
- Fig. 5. *Chlamys (Argopecten) abietis abbotti* n. subsp. Holotype (San Diego Society of Natural History), from exposure at Frontier Housing Project, Loma Portal, San Diego. Length 129.3 mm.; height 117.3 mm. View of the exterior of a right valve. P. 196
- Fig. 6. *Chlamys (Chlamys) hastata ellisi* n. subsp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 2. Length 17.9 mm.; height 20.8 mm. View of the exterior of a left valve. P. 190



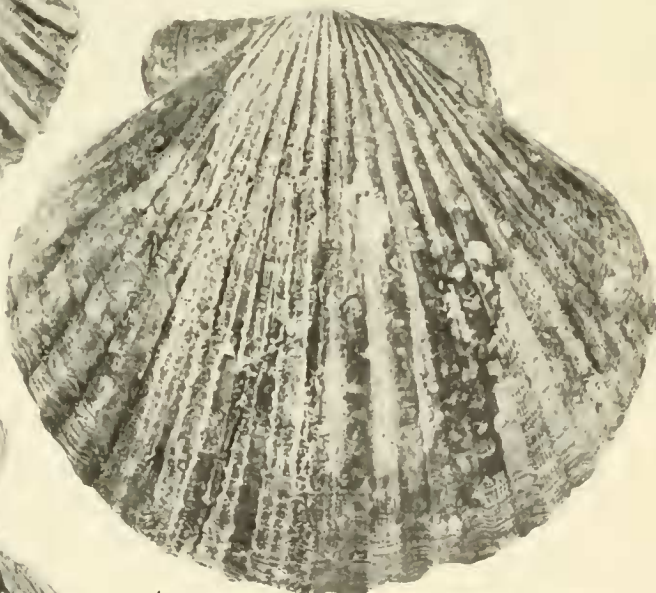
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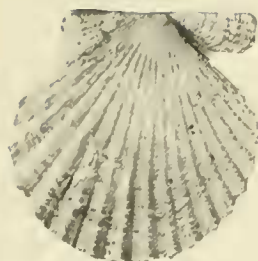
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PLATE 35

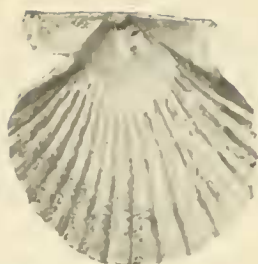
- Fig. 1. *Chlamys (Leptopecten) latiaurata* Conrad. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), second ravine north of Loc. 291 (UCLA), and fifth ravine north (about $\frac{1}{4}$ mile) of the Mexican boundary at west face of a terrace $\frac{3}{4}$ mile east of the coast. Length 17 mm.; height 17.3 mm. View of the exterior of a right valve. P. 203
- Fig. 2. *Chlamys (Argopecten) subdola* Hertlein. Hypotype (California Academy of Sciences), from Loc. 1401 (CAS), first canyon west of Rose Canyon, south slope of Mount Soledad. Length 64 mm.; height 61.3 mm. View of the exterior of a right valve. P. 201
- Fig. 3. *Chlamys (Leptopecten) latiaurata* Conrad. View of the interior of the specimen shown in fig. 1.
- Fig. 4. *Pecten (Litogopecten) dilleri* Dall. Hypotype (University of California at Los Angeles), from Loc. 309 (UCLA), corner of India and Upas streets, San Diego. Length 88.6 mm.; height 88 mm. View of the exterior of a right valve. P. 186
- Fig. 5. *Chlamys (Argopecten) subdola* Hertlein. View of the left valve of the specimen shown in fig. 2.
- Fig. 6. *Chlamys (Chlamys) rubida* Hinds. Hypotype (San Diego Society of Natural History), from Loc. 4736 (SD), India Street near Spruce Street, San Diego. Length 59.8 mm.; height 64 mm. View of the exterior of a left valve.
- Fig. 7. *Pecten (Litogopecten) dilleri* Dall. View of the exterior of the left valve of the specimen shown in fig. 4.
- Fig. 8. *Chlamys (Chlamys) rubida* Hinds. Hypotype (Los Angeles County Museum), from Loc. 107 (CAS), clay quarry at end of Arroyo Drive, San Diego. Length 57.9 mm.; height 52.6 mm. View of the exterior of a right valve, the anterior ear imperfect. P. 193
- Fig. 9. *Chlamys (Argopecten) subdola* Hertlein. Hypotype (San Diego Society of Natural History), from Loc. 408 (SD), road cut 0.1 mile east of Euclid Avenue on north side of Market Street, San Diego. Length 40.5 mm.; height 41.8 mm. View of the exterior of a right valve. P. 201
- Fig. 10. *Pecten (Elabellipecten) steurnsii* Dall. View of the interior of the specimen shown on plate 29, fig. 2. P. 178
- Fig. 11. *Lima (Limaria) orcutti* n. sp. Paratype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 38.6 mm.; height 13.2 mm. View of the interior of a right valve. P. 215



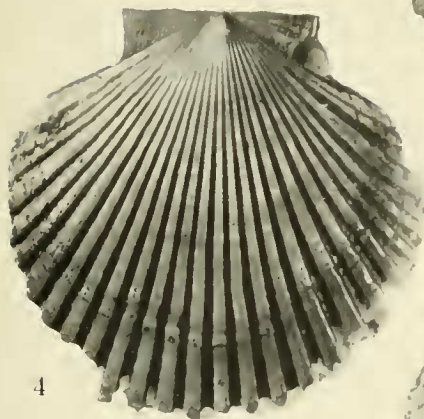
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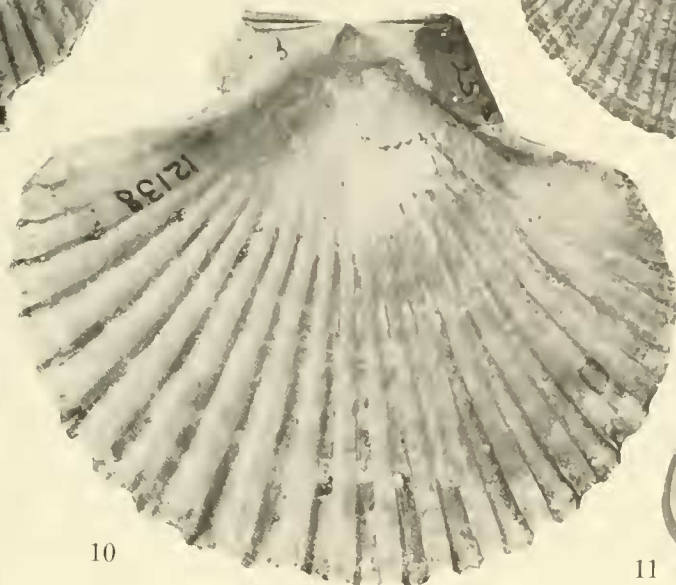
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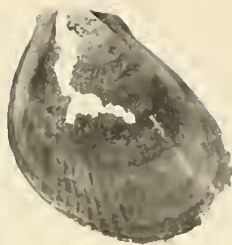
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PLATE 36

- Fig. 1. *Chlamys (Argopecten) abietis abbotti* n. subsp. Holotype (San Diego Society of Natural History), from cut in exposure of strata at Frontier Housing Project, Loma Portal, San Diego. Length 129.0 mm.; height 118.0 mm. View of the exterior of a left valve. Fine fringing lamellae on the sides of the ribs on the upper half of the shell are shown in this illustration. P. 196
- Fig. 2. *Lima (Limaria) oreutti* n. sp. Holotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 35.5 mm.; height 43 mm. View of the exterior of a right valve. P. 215
- Fig. 3. *Lima (Limaria) oreutti* n. sp. View of the interior of the specimen shown in fig. 2.
- Fig. 4. *Lima (Limaria) oreutti* n. sp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in figs. 2 and 3. Length 27.6 mm.; height 34.5 mm. View of the exterior of a left valve.
- Fig. 5. *Lima (Limaria) oreutti* n. sp. View of the interior of the specimen shown in fig. 4.
- Fig. 6. *Chlamys (Argopecten) abietis abbotti* n. subsp. View of the interior of the right valve of the specimen shown in fig. 1.
- Fig. 7. *Chlamys (Lyropecten) cerrosensis* Gabb. Hypotype (California Academy of Sciences), from Loc. 12142 (H. Hemphill Coll.), from San Diego. Length 137 mm.; height (incomplete) 111 mm. View of the exterior of a right valve showing the strong radial striations over the entire valve. P. 209
- Fig. 8. *Pecten (Patinopecten) healeyi* Arnold. Hypotype (California Academy of Sciences) from Loc. 105 (CAS), Pacific Beach, San Diego. Length 28.4 mm.; height 29.5 mm. View of the exterior of a small left valve. P. 183
- Fig. 9. *Pecten (Patinopecten) healeyi* Arnold. Hypotype (California Academy of Sciences), from Loc. 105 (CAS), Pacific Beach, San Diego. Length 37 mm.; height 38.8 mm. View of the exterior of a small right valve showing the smooth early umbonal area. See also plate 33, fig. 9, P. 183



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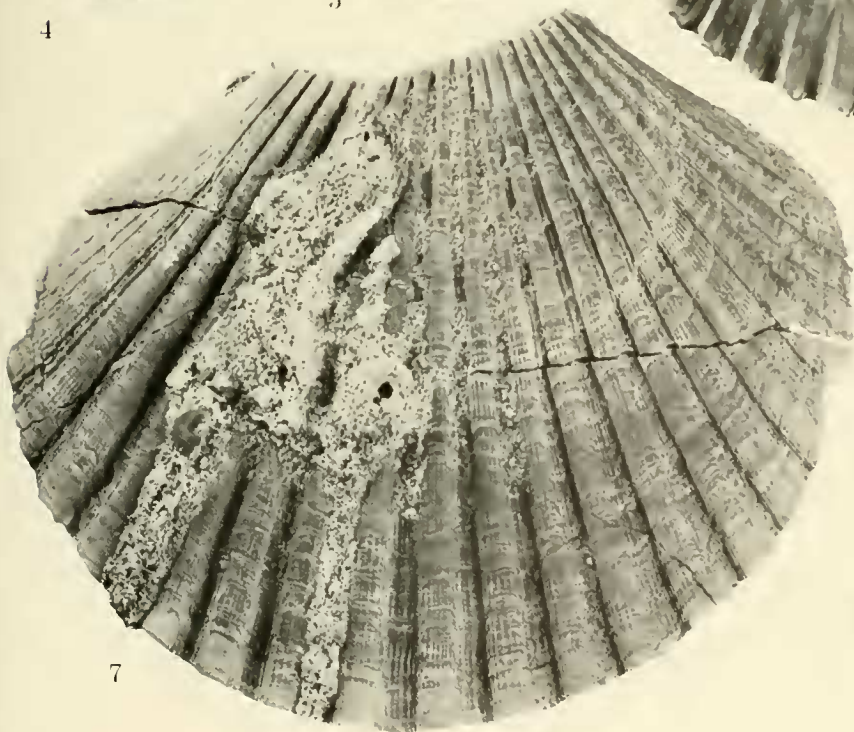
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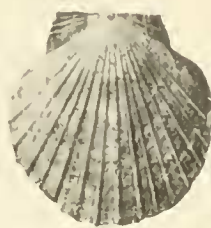
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PLATE 37

- Fig. 1. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co., Calif. (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 43.6 mm.; height 48.8 mm. View of the exterior of a left valve. P. 206
- Fig. 2. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length (incomplete) 46.0 mm.; height (incomplete) 86.5 mm. View of a portion of a right valve on which the radial folds are only faintly developed and concentric undulation is almost lacking. P. 206
- Fig. 3. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 43.6 mm.; height 48.5 mm. View of the exterior of a right valve. P. 206
- Fig. 4. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 56.6 mm.; height 62.5 mm. View of the exterior of a right valve. P. 206
- Fig. 5. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (San Diego Society of Natural History), from Loc. 4735 (SD), India Street near Spruce Street, San Diego. Length 61.8 mm.; height 71.6 mm. View of the interior of a right valve showing cardinal crura. The end of the anterior ear is imperfect as a result of accidental damage since the exterior was drawn as shown in text fig. 10. P. 206
- Fig. 6. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length (incomplete) 54 mm.; height 83.6 mm. View of a portion of a large right valve. P. 206
- Fig. 7. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 72.0 mm.; height 81.2 mm. View of the exterior of a left valve. P. 206
- Fig. 8. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 11.5 mm.; height 12.8 mm. View of the exterior of a juvenile right valve.
- Fig. 9. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 8.3 mm.; height 9 mm. View of the exterior of a juvenile left valve.
- Fig. 10. *Chlamys (Swiftopecten) parmeleei* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 66 mm.; height 75.2 mm. View of the exterior of a left valve.



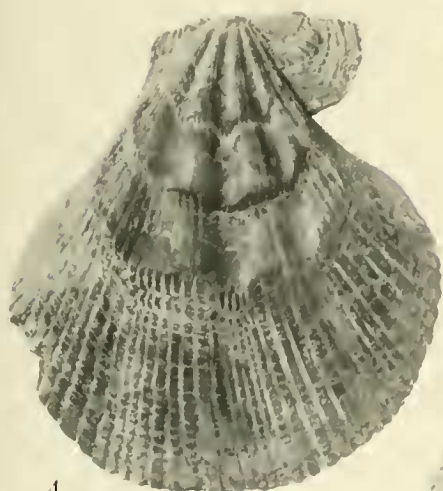
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PLATE 38

- Fig. 1. *Ostrea (Agerostrea) megodon* Hanley. Hypotype (University of California at Los Angeles), from Loc. 2420 (UCLA), soft yellow Pliocene sands exposed in bluffs along Pacific Beach, about $\frac{1}{2}$ mile southeast of False Point, La Jolla quadrangle, San Diego. Height (maximum) 37 mm.; width (maximum) 26.0 mm. View of the exterior of the lower valve. P. 221
- Fig. 2. *Ostrea angelica* Rochebrune. Hypotype (University of California at Los Angeles), from Loc. 303 (UCLA), first prominent cut on west side of the road, at lower entrance to Mt. Hope Cemetery between Imperial Avenue and old Cuyamaca Railroad (36th Street), San Diego. Height (beak to ventral margin) 113.3 mm.; width 81 mm. View of the exterior of a lower valve. P. 216
- Fig. 3. *Ostrea angelica* Rochebrune. View of the interior of the specimen shown in fig. 2.
- Fig. 4. *Ostrea erici* Hertlein. Hypotype (Los Angeles County Museum), from Loc. 124 (LAM), shell and echini stratum 15 feet below the school floor level of "Snyder's Continuation School." Height (beak to ventral margin) 69.6 mm.; width 50.4 mm. View of the interior of an upper valve. P. 217
- Fig. 5. *Ostrea Agerostrea) megodon* Hanley. View of the exterior of the upper valve of the specimen shown in fig. 1.
- Fig. 6. *Ostrea erici* Hertlein. Hypotype (Los Angeles County Museum), from Loc. 107 (LAM), clay quarry at end of Arroyo Drive, San Diego. Height (beak to ventral margin) 65.8 mm.; width 58.6 mm. View of the exterior of an upper valve and marginal portion of the lower valve. P. 217
- Fig. 7. *Ostrea (Agerostrea) megodon* Hanley. View of the interior of the lower valve shown in fig. 1.
- Fig. 8. *Ostrea erici* Hertlein. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 6. Height (beak to ventral margin) 90 mm.; width 86.5 mm. View of the exterior of a lower valve.
- Fig. 9. *Ostrea erici* Hertlein. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 6. Height 97 mm.; width (incomplete) 69.5 mm. View of the interior of a lower valve.

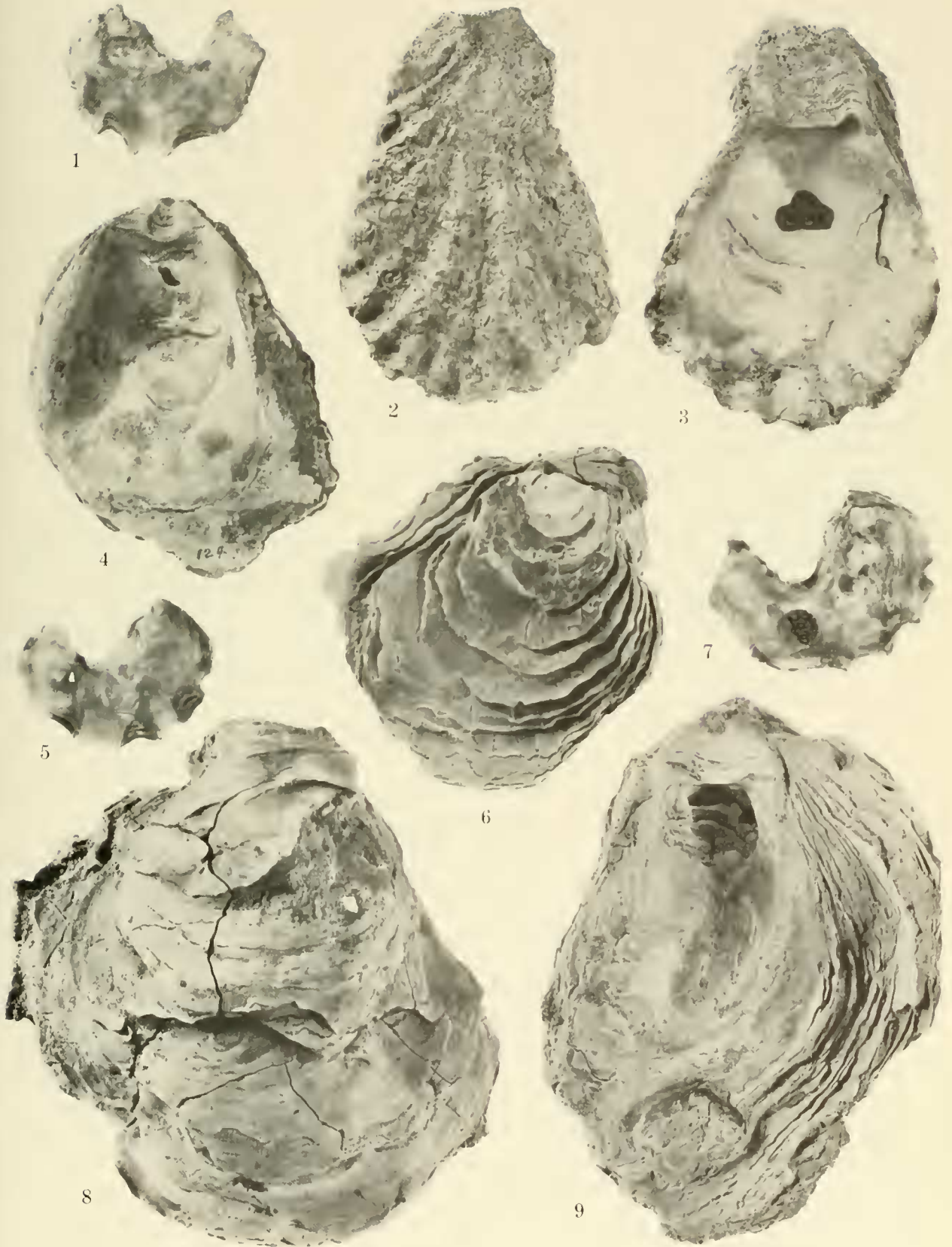
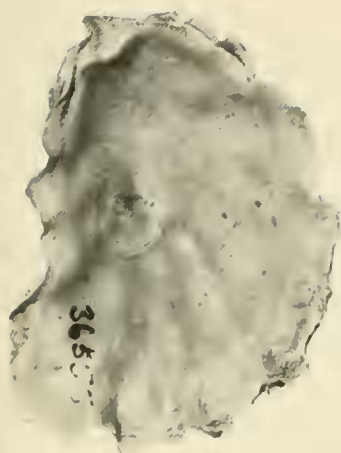


PLATE 39

- Fig. 1. *Ostrea vespertina* Conrad. Hypotype (California Academy of Sciences), from Loc. 36555 (CAS), south side of Tijuana River near the mouth of the valley, at base of hill south of monument road and east of Border Naval Reservation [= Loc. 305A (LAM)]. Height 48 mm.; width 37.5 mm. View of the lower of the lower valve showing denticles along the dorsal margin. P. 218
- Fig. 2. *Ostrea vespertina* Conrad. Hypotype (California Academy of Sciences), from the same locality as specimen shown in fig. 1. Height 46.4 mm.; width 37.4 mm. View of the interior of an upper valve, showing muscle impression and denticles along dorsal margin. P. 218
- Fig. 3. *Ostrea vespertina* Conrad. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), second ravine north of Loc. 294 (UCLA) and fifth ravine north (about $\frac{1}{4}$ mile) of the Mexican boundary, at west face of terrace $\frac{3}{4}$ mile east of the coast. Height 40.6 mm.; width 33.1 mm. View of the interior of an upper valve, showing muscle impression and denticles along dorsal margin. P. 218
- Fig. 4. *Ostrea veatchii* Gabb. Holotype (No. 4502, Academy of Natural Sciences of Philadelphia), Cedros Island, Lower California; Pliocene. Height 75 mm.; width 69 mm. View showing interior of a left valve, completely lacking denticles along the dorsal margin.
- Fig. 5. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum) from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co. (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1913). Height 53.5 mm.; width 46 mm. View of exterior of lower valve showing fluting and area of attachment. P. 218
- Fig. 6. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum), view of upper valve of the specimen shown in fig. 5. P. 218
- Fig. 7. *Ostrea vespertina* Conrad. Hypotype (California Academy of Sciences). View of the exterior of the specimen shown in fig. 2. P. 218
- Fig. 8. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 5. Height 69 mm.; width 74 mm. View of a rather round lower (left) valve.
- Fig. 9. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum). Upper valve of the specimen shown in fig. 8. P. 218



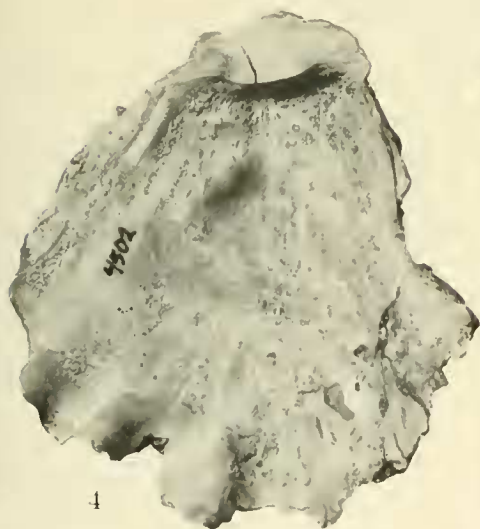
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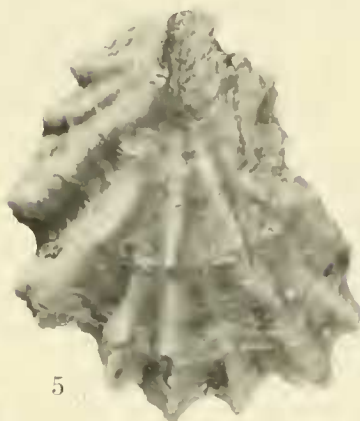
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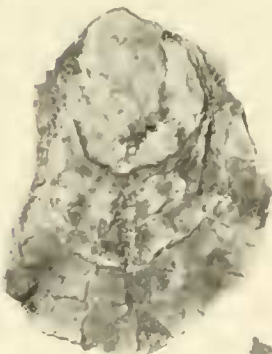
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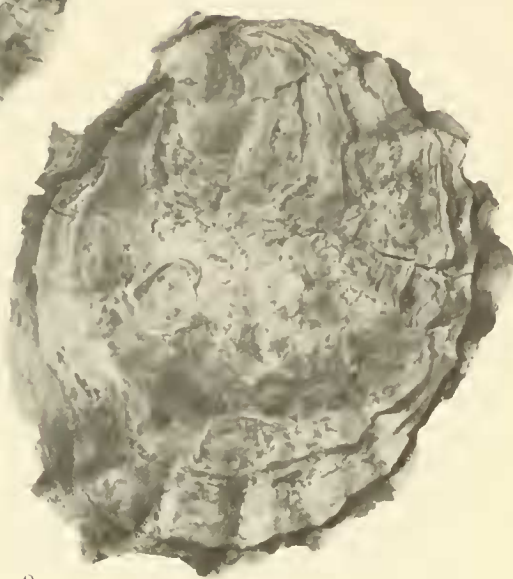
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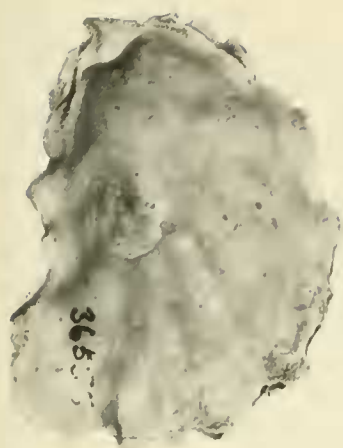
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PLATE 39

- Fig. 1. *Ostrea vespertina* Conrad. Hypotype (California Academy of Sciences), from Loc. 36555 (CAS), south side of Tijuana River near the mouth of the valley, at base of hill south of monument road and east of Border Naval Reservation [= Loc. 305A (LAM)]. Height 48 mm.; width 37.5 mm. View of the lower of the lower valve showing denticles along the dorsal margin. P. 218
- Fig. 2. *Ostrea vespertina* Conrad. Hypotype (California Academy of Sciences), from the same locality as specimen shown in fig. 1. Height 46.4 mm.; width 37.4 mm. View of the interior of an upper valve, showing muscle impression and denticles along dorsal margin. P. 218
- Fig. 3. *Ostrea vespertina* Conrad. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), second ravine north of Loc. 294 (UCLA) and fifth ravine north (about $\frac{1}{4}$ mile) of the Mexican boundary, at west face of terrace $\frac{3}{4}$ mile east of the coast. Height 40.6 mm.; width 33.1 mm. View of the interior of an upper valve, showing muscle impression and denticles along dorsal margin. P. 218
- Fig. 4. *Ostrea vetchii* Gabb. Holotype (No. 4502, Academy of Natural Sciences of Philadelphia), Cedros Island, Lower California; Pliocene. Height 75 mm.; width 69 mm. View showing interior of a left valve, completely lacking denticles along the dorsal margin.
- Fig. 5. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum) from Loc. 305 (LAM), 2400 feet east and 4350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co. (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Height 53.5 mm.; width 46 mm. View of exterior of lower valve showing fluting and area of attachment. P. 218
- Fig. 6. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum), view of upper valve of the specimen shown in fig. 5. P. 218
- Fig. 7. *Ostrea vespertina* Conrad. Hypotype (California Academy of Sciences). View of the exterior of the specimen shown in fig. 2. P. 218
- Fig. 8. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 5. Height 69 mm.; width 74 mm. View of a rather round lower (left) valve.
- Fig. 9. *Ostrea vespertina* Conrad. Hypotype (Los Angeles County Museum). Upper valve of the specimen shown in fig. 8. P. 218



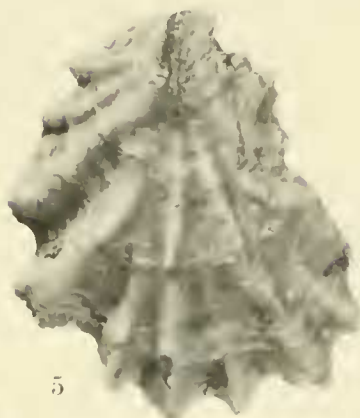
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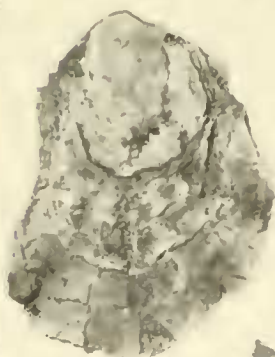
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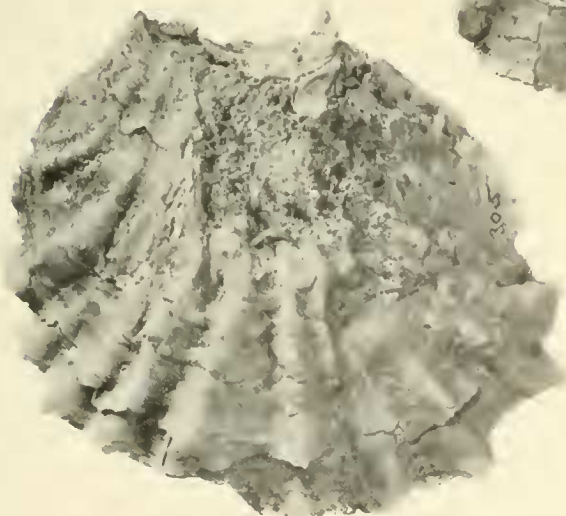
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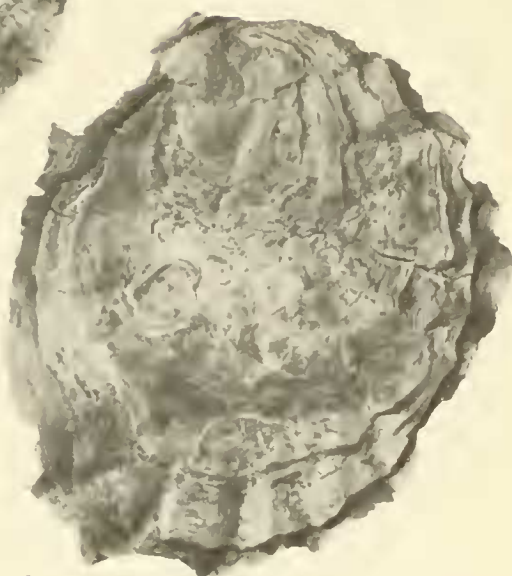
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PLATE 40

- Fig. 1. *Ostrea veatchii* Gabb. Hypotype (San Diego Society of Natural History), from Loc. 6307 (SD), Pacific Beach, San Diego. Length 146.5 mm.; height (including spines) 116.5 mm. View of exterior of a large valve to which other smaller valves are attached. P. 219
- Fig. 2. *Anomia peruviana* d'Orbigny. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 16 mm.; height 12.5 mm. View of exterior of a small upper valve, the margin imperfect. P. 223
- Fig. 3. *Pododesmus macrochisma* Deshayes. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 79 mm.; height 73 mm. View of the exterior of an upper valve. P. 225
- Fig. 4. *Ostrea veatchii* Gabb. Hypotype (San Diego Society of Natural History). View of the interior of the specimen shown in fig. 1. Margin completely lacks denticles. P. 219
- Fig. 5. *Ostrea veatchii* Gabb. Hypotype (Los Angeles County Museum), from Cedros Island, Lower California, Mexico; Pliocene. Length 100 mm.; height 106.5 mm. View of the exterior of the lower valve showing deep plications and spines. P. 219
- Fig. 6. *Ostrea veatchii* Gabb. Hypotype (Los Angeles County Museum). View of the interior of the specimen shown in fig. 5. The margins are devoid of denticles. See also fig. 4 on plate 39. P. 219

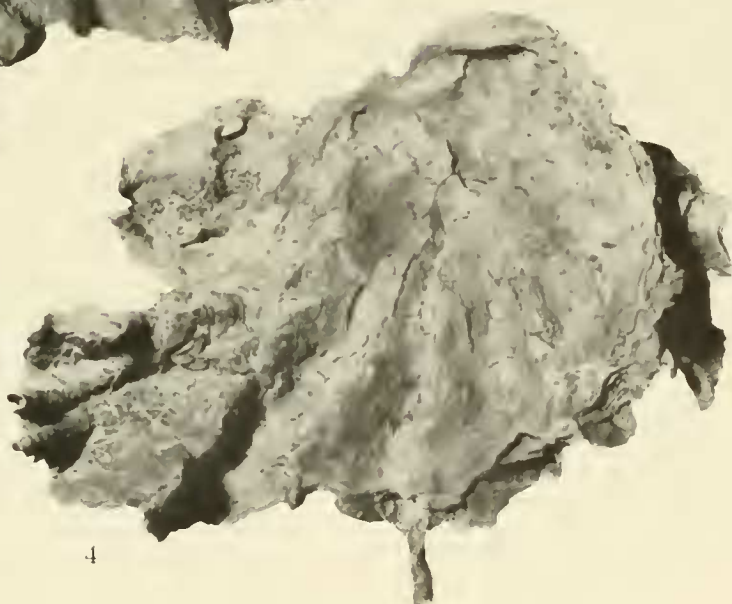
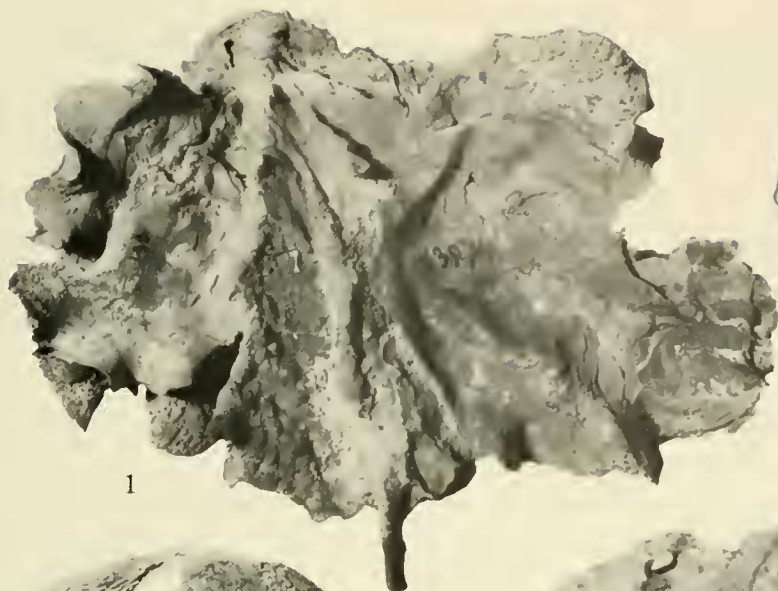


PLATE 11

- Fig. 1. *Gregariella chenui* Recluz. Hypotype (Los Angeles County Museum) from Loc. 305 (CAS), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 4.6 mm.; height 2.5 mm. View of the exterior of a right valve. P. 168
- Fig. 2. *Modiolus sacculifer* Berry. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length (incomplete) 22 mm.; height 10 mm. View showing the projecting anterior end of a left valve. P. 167
- Fig. 3. *Modiolus sacculifer* Berry. View of the exterior of the specimen shown in fig. 2.
- Fig. 4. *Modiolus sacculifer* Berry. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length (anterior end incomplete), 49 mm.; height 34 mm. Ventral margin imperfect. P. 167
- Fig. 5. *Gregariella chenui* Recluz. View of the interior of the specimen shown in fig. 1.
- Fig. 6. *Periploma stenopa* Woodring. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM) at the same elevation. Length 56.5 mm.; height 38.4 mm. View of exterior of a left valve. P. 337
- Fig. 7. *Periploma stenopa* Woodring. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 6. Length (posterior end incomplete) 57 mm.; height 40.5 mm. Dorsal view. P. 337
- Fig. 8. *Anomia peruviana* d'Orbigny. Hypotype (California Academy of Sciences), from Loc. 1100 (CAS), strata in upper part of Pliocene section at Pacific Beach. Length 35.5 mm.; height (incomplete) 35.8 mm. View of the exterior of an upper valve, the dorsal area incomplete. P. 223
- Fig. 9. *Pododesmus macrochisma* Deshayes. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 62 mm.; height 58.9 mm. View of the exterior of an upper valve. P. 225
- Fig. 10. *Mytilus (Crenomytilus) coulingensis sternbergi* new subspecies. Paratype (Los Angeles County Museum), from Loc. 302 (LAM) exposure across the street from the house at 2840 Columbia Street, San Diego. Length (incomplete) 48.8 mm.; height (incomplete) 34 mm. View of the interior of the umbonal portion of a left valve. P. 163
- Fig. 11. *Crenella inflata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3 mm.; height 2.3 mm. View of the exterior of a right valve. P. 171
- Fig. 12. *Pododesmus macrochisma* Deshayes. Hypotype (University of California at Los Angeles), from Loc. 2420 (UCLA), soft sands of Pliocene age at Pacific Beach. Length 52.5 mm.; height 46.8 mm. View of the interior of an upper valve. P. 225
- Fig. 13. *Pododesmus macrochisma* Deshayes. View of the exterior of the specimen shown in fig. 12.
- Fig. 14. *Mytilus (Crenomytilus) coulingensis sternbergi* n. subsp. Holotype (Los Angeles County Museum), from Loc. 107 (LAM), 100-foot bluff with fossiliferous concretions in clay quarry at end of Arroyo Drive, San Diego. Length 238 mm.; height 134 mm. View of the exterior of the left valve. P. 163
- Fig. 15. *Macoma (Rerithaerus) indentata tenuirostris* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 29.3 mm.; height 16 mm. View of the exterior of a right valve. P. 297
- Fig. 16. *Himmites giganteus* Gray. Hypotype (Los Angeles County Museum), from strata of Pliocene age at Pacific Beach. Length 73.0 mm.; height 76.4 mm. View of the exterior of an upper valve. P. 211



PLATE 42

- Fig. 1. *Gregariella chenii* Recluz. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill 100 feet west and 440 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 4.6 mm.; height 2.5 mm. Enlarged view of the exterior of a right valve, also illustrated on plate 41, fig. 1.
- Fig. 2. *Pandora (Heteroclidus) punctata* Conrad. Hypotype (University of California at Los Angeles), from Loc. 1386 (UCLA), *Dosinia* beds in cut bank along a ravine road just below the southeast corner of the Federal Building in Balboa Park, San Diego. Length (incomplete) 28 mm.; height (incomplete) 12 mm. View of the hinge of a left valve. P. 336
- Fig. 3. *Pandora (Heteroclidus) punctata* Conrad. Hypotype (University of California at Los Angeles), from the same locality as the specimen shown in fig. 2. Length (incomplete) 34.5 mm.; height (incomplete) 13.8 mm. View of the hinge of a right valve. P. 336
- Fig. 4. *Aeidimytillus adamsianus* Dunker. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 18.9 mm.; height 7.2 mm. View of the exterior of a right valve. P. 164
- Fig. 5. *Aeidimytillus adamsianus* Dunker. View of the interior of a specimen shown in fig. 4.
- Fig. 6. *Septifer bifurcatus* Conrad. Hypotype (San Diego Society of Natural History), from Loc. 47 (SDSC), south side of Tijuana River near mouth of valley; east side of mouth of prominent gully west of Goat Canyon, southeast $\frac{1}{4}$, Sec. 8, T. 19 S., R. 2 W., (See U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1953). Length 18.3 mm.; height 10.3 mm. View of the interior of a left valve. P. 165
- Fig. 7. *Modiolus rectus* Conrad. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM) at the same elevation. Length (anterior end incomplete) 55 mm.; height 41.8 mm. View of the exterior of a right valve. P. 166
- Fig. 8. *Gregariella chenii* Recluz. View of the interior of the specimen shown in fig. 1.
- Fig. 9. *Pandora (Heteroclidus) punctata* Conrad. Hypotype (San Diego Society of Natural History), from Loc. 21 (SD), embankment at the beach at west end of Diamond Street, Pacific Beach. Length 41.5 mm.; height 25.8 mm. View of the exterior of a right valve. P. 336
- Fig. 10. *Pandora (Heteroclidus) punctata* Conrad. View of the exterior of the left valve of the specimen shown in fig. 9.
- Fig. 11. *Thracia kanakoffi* n. sp. Holotype (Los Angeles County Museum), from Loc. 291 (LAM), silt beds exposed in a gully in the center of the south $\frac{1}{2}$ Sec. 27, T. 4 N., R. 15 W., San Bernardino Base and Meridian; $\frac{1}{2}$ mile south of the Humphrey railroad station, Los Angeles Co., Calif.; Pico formation, middle Pliocene. Length 81.0 mm.; height 54.2 mm. View of the exterior of the right valve. P. 338
- Fig. 12. *Septifer bifurcatus* Conrad. View of the exterior of the specimen shown in fig. 6.
- Fig. 13. *Thracia kanakoffi* n. sp. Paratype (San Diego Society of Natural History), from Loc. 34 (SD), northeast corner of India and Thorn streets, San Diego. Length 48 mm.; height 34.4 mm. View of the exterior of a left valve.
- Fig. 14. *Thracia kanakoffi* n. sp. View of the left valve of the specimen shown in fig. 11.
- Fig. 15. *Thracia kanakoffi*. Dorsal view of the specimen shown in figs. 11 and 12. A low ridge near the right posterior dorsal margin, a characteristic feature of this species, is visible in this view.

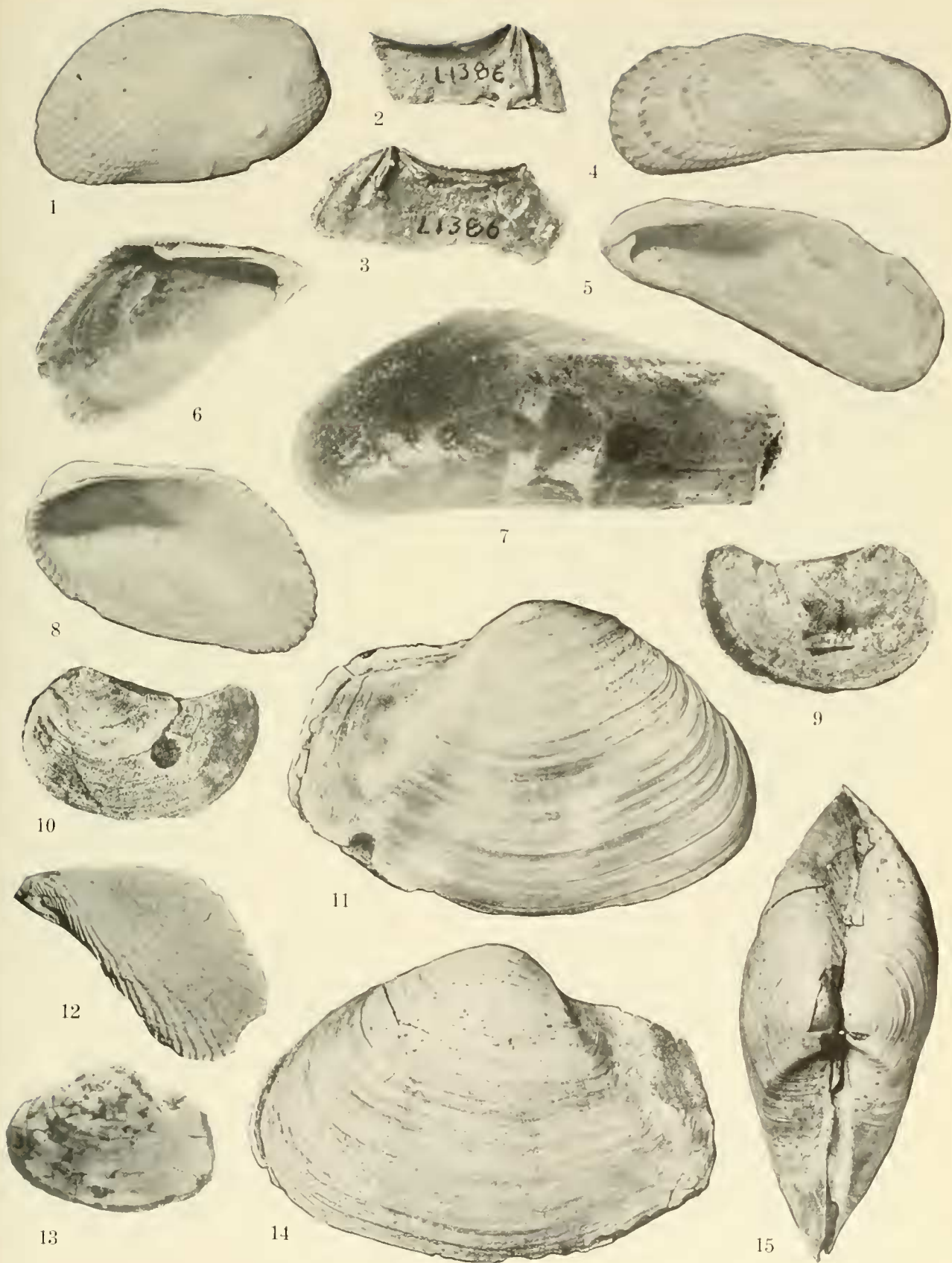


PLATE 43

- Fig. 1. *Milneria minima* Dall. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co., Calif. (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 5.3 mm.; height 3.2 mm. View of the exterior of a right valve. P. 234
- Fig. 2. *Milneria minima* Dall. View of the interior of the specimen shown in fig. 1.
- Fig. 3. *Cyclocardiu ventricosu* Gould. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 16.2 mm.; height 14.9 mm. View of the interior of a left valve. P. 231
- Fig. 4. *Cyclocardiu occidentale* Conrad. Hypotype (University of California at Los Angeles), from Loc. 2359 (UCLA), in small canyon parallel to and about 0.2 mile west of the mouth of Rose Canyon and 0.4 mile north of Garnet Avenue, La Jolla quad., San Diego. Length 11.6 mm.; height 12 mm. View of the interior of a right valve. P. 230
- Fig. 5. *Cyclocardiu occidentale* Conrad. Hypotype (University of California at Los Angeles), from North Snyder School, Cabrillo Freeway, San Diego. Length 14 mm.; height 14 mm. View of the interior of a left valve. P. 230
- Fig. 6. *Cyclocardiu occidentale* Conrad. View of the exterior of the valve shown in fig. 5.
- Fig. 7. *Diplodonta (Felaniella) cornea* Reeve. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length (incomplete) 8.5 mm. View showing hinge of a right valve. P. 253
- Fig. 8. *Cyclocardiu ventricosu* Gould. View of the exterior of the specimen shown in fig. 3.
- Fig. 9. *Cyclocardiu occidentale* Conrad. View of the exterior of the specimen shown in fig. 4.
- Fig. 10. *Cyclocardiu occidentale* Conrad. Hypotype (University of California at Los Angeles), from the same locality as the specimen shown in fig. 4. Length 11 mm.; height 11 mm. View of the exterior of a small right valve. P. 230
- Fig. 11. *Cyclocardiu occidentale* Conrad. Hypotype (University of California at Los Angeles), from the same locality as the specimen shown in fig. 4. Length 9.5 mm.; height 9.8 mm.
- Fig. 12. *Chama pellucida* Broderip. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 26.6 mm.; height (incomplete) 27 mm. View of the exterior of an upper valve. P. 227
- Fig. 13. *Diplodonta (Felaniella) cornea* Reeve. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 10.5 mm.; height 10.5 mm. View of the interior of a left valve. P. 253
- Fig. 14. *Milneria minima* Dall. View of enlarged portion of the specimen shown in fig. 2, showing hinge.
- Fig. 15. *Chama pellucida* Broderip. View of the interior of the specimen shown in fig. 12.
- Fig. 16. *Glans subquadrata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 5.5 mm.; height 3.7 mm.
- Fig. 17. *Thyasira gouldii* Philippi. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.1 mm.; height 4.3 mm. P. 255
- Fig. 18. *Glans subquadrata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.5 mm.; height 3.3 mm. View of the exterior of a left valve. P. 232
- Fig. 19. *Glans subquadrata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.6 mm.; height 2.9 mm. View of the interior of a right valve. P. 232
- Fig. 20. *Diplodonta (Felaniella) cornea* Reeve. View of the exterior of the specimen shown in fig. 13.
- Fig. 21. *Thyasira gouldii* Philippi. Hypotype (University of California at Los Angeles), from Loc. 294 (UCLA), 200 feet north of the Mexican boundary and $\frac{3}{4}$ mile from the coast. Pliocene exposure in east-west ravine, tributary to a larger south-north ravine at right angle in first terrace above the Tiajuana River plain. Length 8.1 mm.; height 8.1 mm. View of the exterior of a right valve. P. 255
- Fig. 22. *Glans subquadrata* Carpenter. View of the interior of the specimen shown in fig. 16.
- Fig. 23. *Verticordia (Trigomulina) ornata* d'Orbigny. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 5.3 mm.; height 4.3 mm. View of the exterior of a left valve. P. 344
- Fig. 24. *Crassinella brunneri* Arnold. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 8.7 mm.; height (incomplete) 8.0 mm. View of the interior of a left valve, the apical portion lacking. P. 228
- Fig. 25. *Crassinella brunneri* Arnold. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 7.0 mm.; height 6.1 mm. View of the interior of a right valve. P. 228
- Fig. 26. *Verticordia (Trigomulina) ornata* d'Orbigny. View of the exterior of the right valve of the specimen shown in fig. 23.
- Fig. 27. *Verticordia (Trigomulina) ornata* d'Orbigny. View of the interior of the specimen shown in fig. 26.
- Fig. 28. *Crassinella brunneri* Arnold. View of the exterior of the specimen shown in fig. 24.
- Fig. 29. *Crassinella brunneri* Arnold. View of the exterior of the specimen shown in fig. 25.
- Fig. 30. *Glans subquadrata* Carpenter. View of the exterior of the specimen shown in fig. 19.
- Fig. 31. *Verticordia (Trigomulina) ornata* d'Orbigny. View of the interior of the specimen shown in fig. 23.

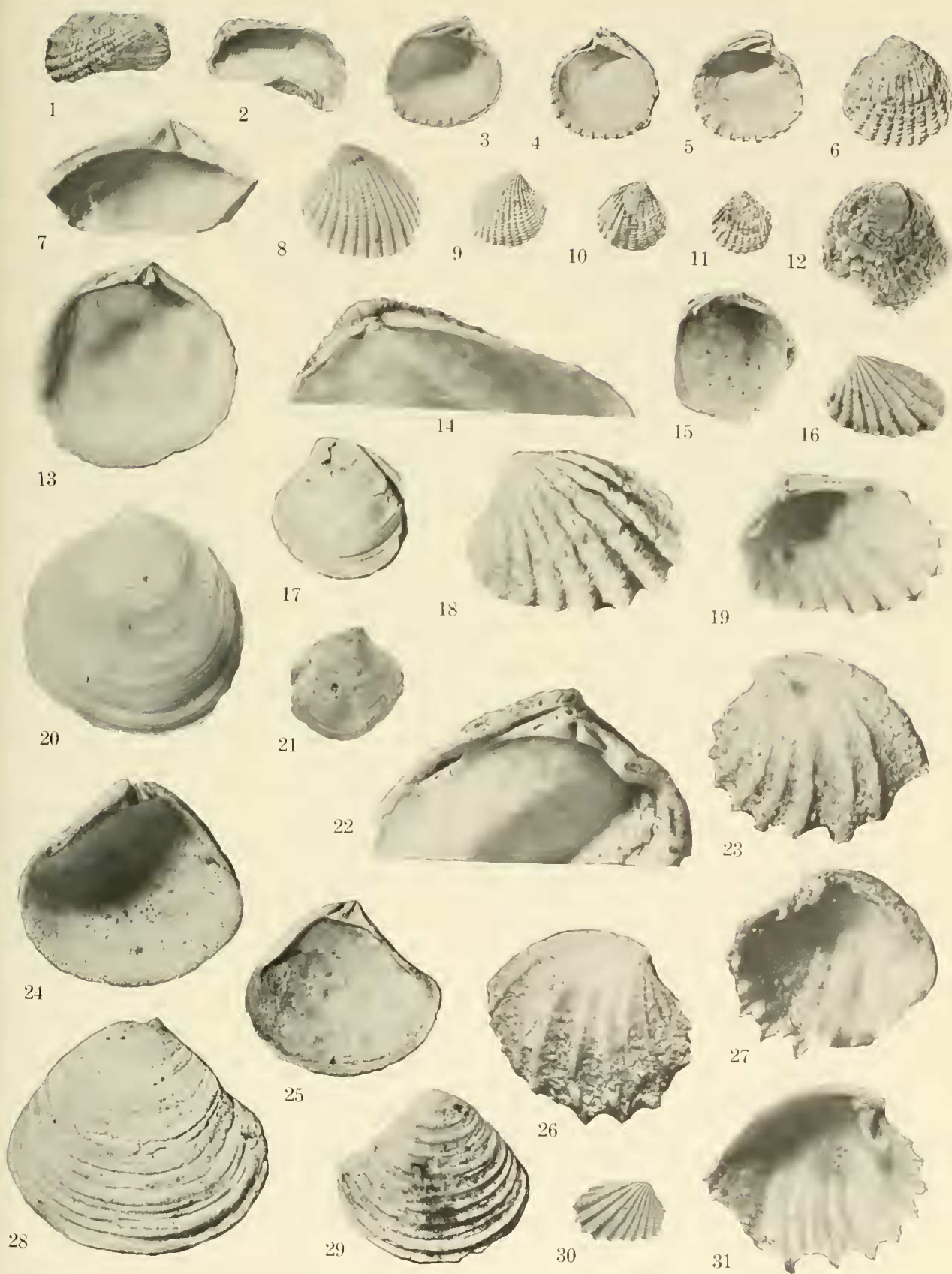


PLATE 44

- Fig. 1. *Aligena diegoana* n. sp. Paratype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM) at the same elevation. Length 6.3 mm.; height 5.3 mm. View of the exterior of a right valve. P. 235
- Fig. 2. *Mysella tumida* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 2.4 mm.; height 2.0 mm. View of the exterior of a right valve. P. 239
- Fig. 3. *Mysella tumida* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 2.3 mm.; height 1.8 mm. View of the exterior of a left valve. P. 239
- Fig. 4. *Mysella tumida* Carpenter. View of the interior of the specimen shown in fig. 2.
- Fig. 5. *Mysella tumida* Carpenter. View of the interior of the specimen shown in fig. 3.
- Fig. 6. *Aligena diegoana* n. sp. View of the interior of the specimen shown in fig. 1.
- Fig. 7. *Mysella tumida* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 2.9 mm.; height 2.1 mm. View of the interior of a left valve. P. 239
- Fig. 8. *Mysella tumida* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 3.2 mm.; height 2.7 mm. View of the exterior of a left valve. P. 239
- Fig. 9. *Pristes oblongus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3.4 mm.; height 2.6 mm.
- Fig. 10. *Pristes oblongus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 2.9 mm.; height 2.3 mm. View of the interior of a right valve. P. 240
- Fig. 11. *Kellia laperousii* Deshayes. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.0 mm.; height 3.3 mm. View of the interior of a left valve. P. 237
- Fig. 12. *Mysella tumida* Carpenter. View of the exterior of the specimen shown in fig. 7.
- Fig. 13. *Pristes oblongus* Carpenter. View of the exterior of the specimen shown in fig. 9.
- Fig. 14. *Pristes oblongus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3.0 mm.; height 2.6 mm. View of the interior of a left valve. P. 240
- Fig. 15. *Petricola (Rupellaria) carditoides* Conrad. Hypotype (San Diego Society of Natural History), from Loc. 331 (SD), 200 feet north of the Mexican boundary and $\frac{3}{4}$ mile from the coast, exposure of strata of Pliocene age in east-west ravine tributary to a larger south-north ravine at right angle, in first terrace above the Tiajuana river plain. Length 29.8 mm.; height 15.7 mm. View of the exterior of a left valve. P. 283
- Fig. 16. *Petricola (Rupellaria) carditoides* Conrad. View of the interior of the specimen shown in fig. 15.
- Fig. 17. *Arinopsida serricata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3.5 mm.; height 3.3 mm. View of the interior of a left valve. P. 257
- Fig. 18. *Arinopsida serricata* Carpenter. View of the exterior of the specimen shown in fig. 17.
- Fig. 19. *Kellia laperousii* Deshayes. View of the exterior of the specimen shown in fig. 11.
- Fig. 20. *Transennella tantilla* Gould. Hypotype (Los Angeles County Museum), from Loc. 305C. Length 3.7 mm.; height 3.0 mm. P. 282
- Fig. 21. *Psephidia stephensae* n. sp. Holotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3.0 mm.; height 2.7 mm. View of the interior of a right valve. P. 280
- Fig. 22. *Psephidia stephensae* n. sp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.7 mm.; height 2.6 mm. View of the interior of a right valve. P. 280
- Fig. 23. *Transennella tantilla* Gould. (Los Angeles County Museum), from the same locality as the specimen shown in fig. 27. Length 5.8 mm.; height 4.8 mm.
- Fig. 24. *Psephidia stephensae* n. sp. Holotype. View of the exterior of the specimen shown in fig. 21.
- Fig. 25. *Transennella tantilla* Gould. Hypotype (University of California at Los Angeles), from Loc. 1386 (UCLA), *Dosinia* beds in cut bank 338 feet farther along the ravine road (from Loc. 1385), just below the southeast corner of the Federal Building, Balboa Park, San Diego. Length 7.0 mm.; height 6.0 mm. View of the exterior of a left valve. P. 282
- Fig. 26. *Psephidia stephensae* n. sp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3.9 mm.; height 3.2 mm. View of the interior of a left valve. P. 280
- Fig. 27. *Transennella tantilla* Gould. Hypotype (Los Angeles County Museum), from Loc. 309 (LAM), two canyons east of Kate Sessions School; approximately 0.3 mile west of Balboa Avenue from U.S. Highway 101. Length 5.5 mm.; height 4.5 mm. View of the interior of a left valve. P. 282

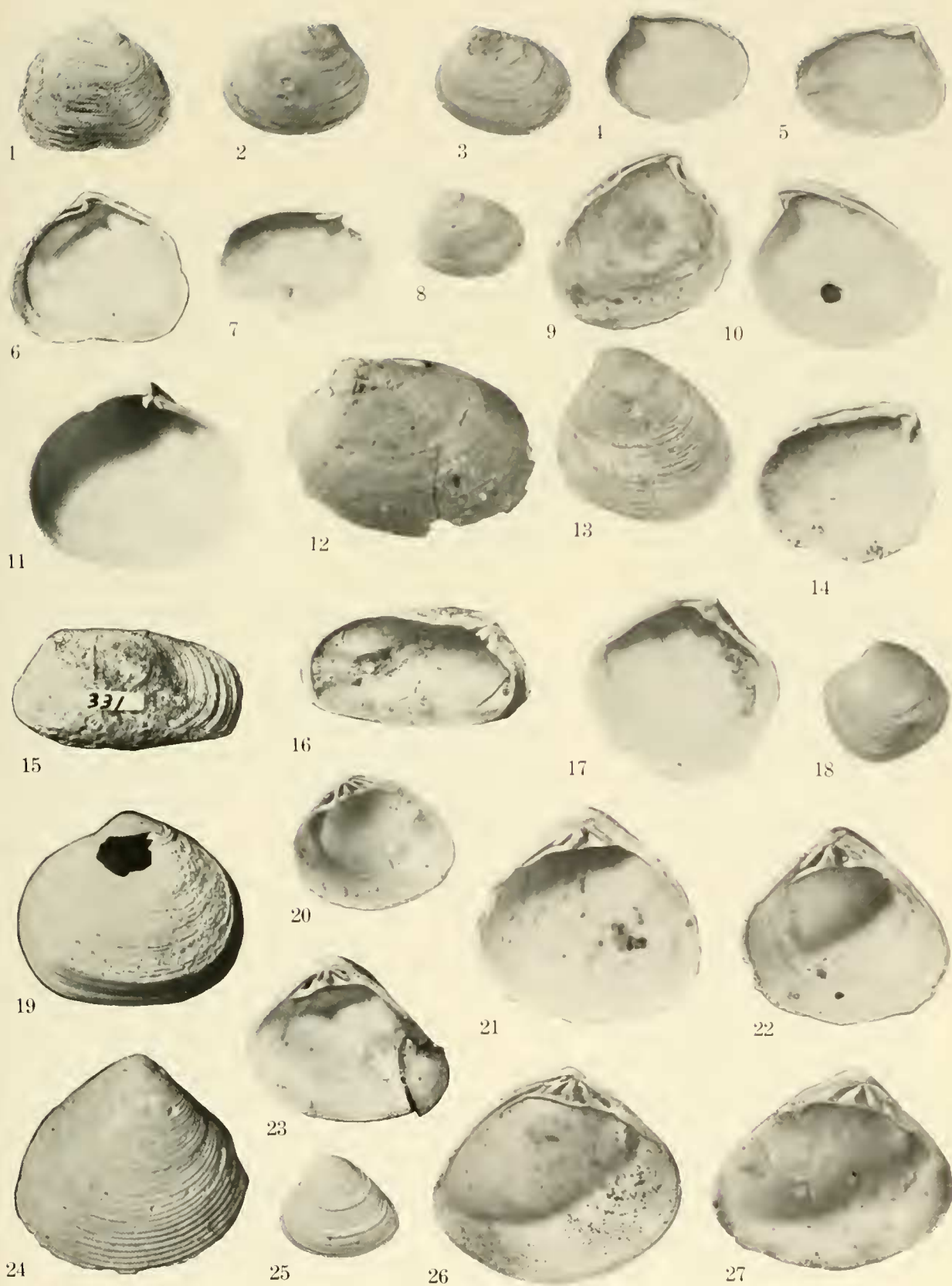


PLATE 45

- Fig. 1. *Lucina (Luciniscia) nuttalli* Conrad. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co., (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 26.6 mm.; height 19.8 mm. View of the exterior of a right valve. P. 245
- Fig. 2. *Lucina (Luciniscia) nuttalli* Conrad. View of the interior of the specimen shown in fig. 1.
- Fig. 3. *Lucina (Luciniscia) nuttalli* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 25.8 mm.; height 18.9 mm. View of the exterior of a left valve.
- Fig. 4. *Lucina (Luciniscia) nuttalli* Conrad. View of the interior of the specimen shown in fig. 3.
- Fig. 5. *Pristes oblongus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3.3 mm.; height 3.0 mm. View of the exterior of a right valve. P. 239
- Fig. 6. *Aligona diegoana* n. sp. Paratype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM) at the same elevation. Length 5.7 mm.; height 5.1 mm. View of the exterior of a right valve. P. 235
- Fig. 7. *Aligona diegoana* n. sp. Holotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 7.9 mm.; height 6.1 mm. View of the interior of a right valve. P. 235
- Fig. 8. *Pristes oblongus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.1 mm.; height 4.0 mm. View of the exterior of a left valve. P. 239
- Fig. 9. *Pristes oblongus* Carpenter. View of the interior of the specimen shown in fig. 5.
- Fig. 10. *Aligona diegoana* n. sp. Paratype from the same locality as the specimen shown in fig. 1. Length 8.0 mm.; height 6.4 mm. View of the interior of a left valve. P. 235
- Fig. 11. *Aligona diegoana* n. sp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 8.5 mm.; height 6.7 mm. View of the exterior of a right valve. P. 235
- Fig. 12. *Pristes oblongus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 3.2 mm.; height 2.7 mm. View of the exterior of a left valve. P. 239
- Fig. 13. *Aligona diegoana* n. sp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 7.5 mm.; height 6.0 mm. View of the exterior of a right valve. P. 235
- Fig. 14. *Miltha (Miltha) xantusi* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 6. Length 61.0 mm.; height 60.0 mm. View of the exterior of a left valve which has been bored by a predator. P. 250
- Fig. 15. *Miltha (Miltha) xantusi* Dall. View of the interior of the specimen shown in fig. 14.
- Fig. 16. *Miltha (Miltha) xantusi* Dall. Hypotype (California Academy of Sciences), from Loc. 1402 (CAS), on end of point between Cabrillo Canyon and a gulch about 100 meters south of the west end of Laurel Street bridge across Cabrillo Canyon, Balboa Park, San Diego. Length 72.5 mm.; height 68.8 mm. View of the exterior of a right valve. P. 250
- Fig. 17. *Miltha (Miltha) xantusi* Dall. Hypotype (California Academy of Sciences), from the same locality as the specimen shown in fig. 16. Length 58.0 mm.; height 61.3 mm. View of a right valve, smaller and more ovate in outline than the specimen shown in fig. 16. P. 250

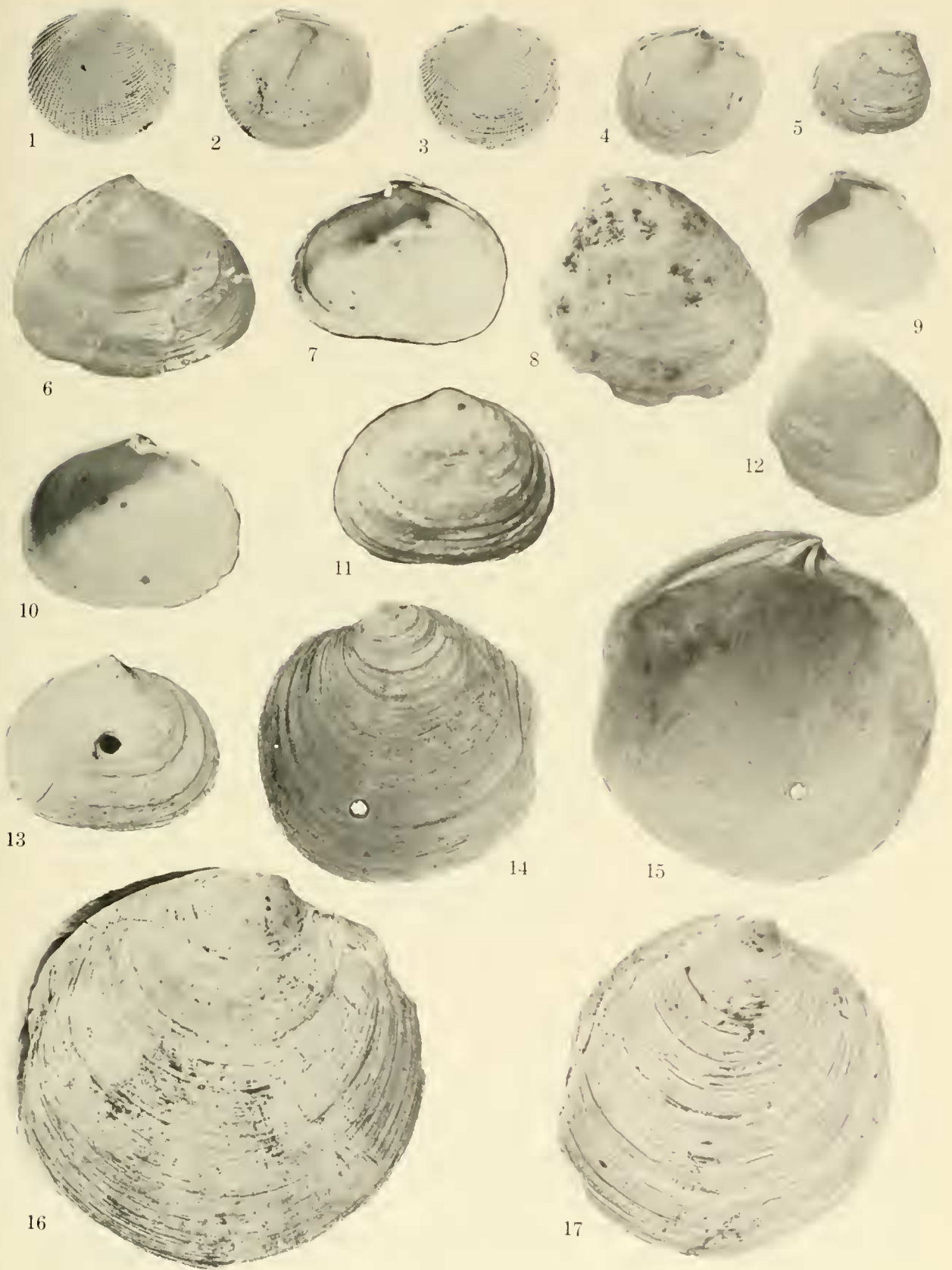


PLATE 46

- Fig. 1. *Lucina (Here) excavata* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co., (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 15.5 mm.; height 14.2 mm. View of the exterior of a left valve. P. 244
- Fig. 2. *Lucina (Here) excavata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen illustrated in fig. 1. Length 17 mm.; height 17 mm. View of the interior of a left valve.
- Fig. 3. *Lucina (Here) excavata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen illustrated in fig. 1. Length 19 mm.; height 19 mm. View of the interior of a right valve.
- Fig. 4. *Nemocardium (Keenaea) centifilosum* Carpenter. Hypotype (San Diego Society of Natural History), from the corner of India and Upas streets, San Diego. Length 16 mm.; height 16 mm. View of the exterior of a right valve. P. 263
- Fig. 5. *Nemocardium (Keenaea) centifilosum* Carpenter. View of the left valve of the specimen shown in fig. 4.
- Fig. 6. *Lucina (Parvilucina) intensa* Dall. Syntype No. 698D (California Academy of Sciences), from the San Diego well, Balboa Park, San Diego. Length 7.7 mm.; height 6.5 mm. View of the exterior of a left valve. P. 247
- Fig. 7. *Lucina (Parvilucina) intensa* Dall. View of the interior of the specimen shown in fig. 6.
- Fig. 8. *Lucina (Luciniscia) nuttalli antecedens* Arnold. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 18.3 mm.; height 16.9 mm. View of the exterior of a right valve. P. 246
- Fig. 9. *Lucina (Luciniscia) nuttalli antecedens* Arnold. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 17 mm.; height 15.3 mm. View of a left valve. P. 246
- Fig. 10. *Nemocardium (Keenaea) centifilosum* Carpenter. Hypotype (California Academy of Sciences), from Loc. 12078 (CAS) San Diego well, Balboa Park, San Diego. Length 16.5 mm.; height 16.5 mm. View of the exterior of a right valve. P. 263
- Fig. 11. *Lucina (Epilucina) californica* Conrad. Hypotype (San Diego Society of Natural History), from Loc. 80 (SD), middle part of gulch about 1/3 mile west of the mouth of Rose Canyon, south slope of Mount Soledad, San Diego. Length 13.4 mm.; height 13.5 mm. View of the exterior of a right valve. P. 247
- Fig. 12. *Lucina (Lucinoma) annulata* Reeve. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 44.6 mm.; height 38.5 mm. View of the exterior of a right valve. P. 247
- Fig. 13. *Lucina (Luciniscia) nuttalli antecedens* Arnold. View of the interior of the specimen shown in fig. 8.
- Fig. 14. *Lucina (Luciniscia) nuttalli antecedens* Arnold. View of the interior of the specimen shown in fig. 9.
- Fig. 15. *Nemocardium (Keenaea) centifilosum* Carpenter. View of the interior of the specimen shown in fig. 10.
- Fig. 16. *Lucina (Epilucina) californica* Conrad. View of the interior of the specimen shown in fig. 11.
- Fig. 17. *Lucina (Parvilucina) intensa* Dall. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), from west side of next gully east of Loc. 305 (LAM) at the same elevation. Length 6.0 mm.; height 5.3 mm. View of the exterior of a left valve. P. 247
- Fig. 18. *Cardium (Dallocardia) quadragenarium* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length (incomplete) 60 mm.; height (incomplete) 49 mm. View of the interior dorsal portion of a right valve. P. 259
- Fig. 19. *Lucina (Lucinoma) annulata* Reeve. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 60.8 mm.; height 56.9 mm. View of the interior of a right valve. P. 247
- Fig. 20. *Cardium (Dallocardia) quadragenarium* Conrad. View of the exterior of the specimen shown in fig. 18.
- Fig. 21. *Cardium (Clinocardium) nuttalli* Conrad. Hypotype (Los Angeles County Museum), from Loc. 407 (LAM), 100-foot bluff with fossiliferous concretions in clay quarry at end of Arroyo Drive, San Diego. Length 80 mm.; height 82.4 mm.
- Fig. 22. *Lucina (Parvilucina) intensa* Dall. Hypotype (Los Angeles County Museum), from Loc. 318 (LAM), Knox Ranch hill, just above the gates and the cow shed; 200 feet from the road and 30 feet above the valley floor, near Mexican boundary. Length 6.4 mm.; height 6.9 mm. View of the interior of a right valve. P. 247
- Fig. 23. *Cardium (Dallocardia) quadragenarium* Conrad. Hypotype (California Academy of Sciences), from Loc. 1402 (CAS), on end of point between Cabrillo Canyon and a gulch about 100 meters south of the west end of Laurel Street bridge across Cabrillo Canyon in Balboa Park, San Diego. Length 50 mm.; height 50.5 mm. View of the exterior of a left valve. P. 259

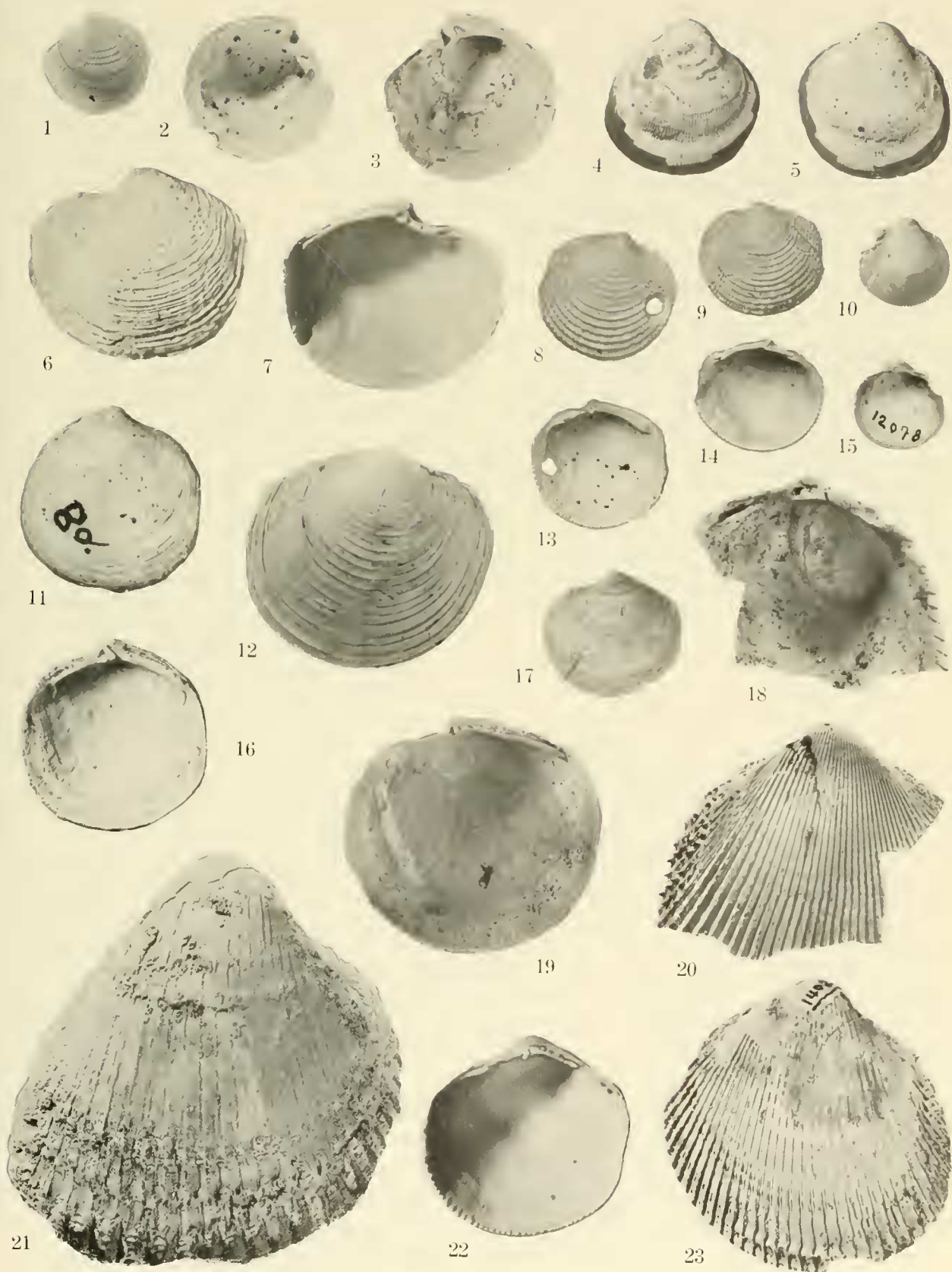


PLATE 47

- Fig. 1. *Pandora (Pandorella) bilirata* Conrad. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 13 mm.; height 7.5 mm. View of the interior of the specimen shown on Plate 48, fig. 14. P. 335
- Fig. 2. *Dosinia (Dosinia) ponderosa diegoana* n. subsp. Paratype (California Academy of Sciences), from Loc. 1402 (CAS), on end of a point between Cabrillo Canyon and a gulch about 100 meters south of the west end of the Laurel Street bridge across Cabrillo Canyon, Balboa Park, San Diego. Length (incomplete) approximately 91.5 mm. View showing hinge of a left valve. P. 265
- Fig. 3. *Dosinia (Dosinia) ponderosa diegoana* n. subsp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 114 mm.; height 111 mm. View of the interior of a right valve. P. 265
- Fig. 4. *Compsomya subdiaphana* Carpenter. Hypotype (California Academy of Sciences), from Loc. 1404 (CAS), southeast corner of India and Upas streets, San Diego. Length 41.6 mm.; height 35 mm. View of the exterior of the right valve. P. 269
- Fig. 5. *Psephidia ovalis* Dall. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 4.2 mm.; height 3 mm. View of the exterior of a left valve shown on plate 51, fig. 9. P. 280
- Fig. 6. *Dosinia (Dosinia) ponderosa diegoana* n. subsp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 117 mm.; height 120 mm. View showing dorsal area of a specimen. P. 265
- Fig. 7. *Compsomya subdiaphana* Carpenter. View showing the dorsal area of both valves of the specimen shown in fig. 4.
- Fig. 8. *Dosinia (Dosinia) ponderosa diegoana* n. subsp. Holotype (California Academy of Sciences), from the same locality as the specimen shown in fig. 2. Length 121 mm.; height 130 mm. View of the exterior of the right valve. P. 265
- Fig. 9. *Psephidia ovalis* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 5. Length 4.1 mm.; height 3.1 mm. View of the exterior of a right valve shown on plate 51, fig. 8. P. 280
- Fig. 10. *Dosinia (Dosinia) ponderosa diegoana* n. subsp. View of the dorsal area of both valves of the holotype shown in fig. 8. P. 265

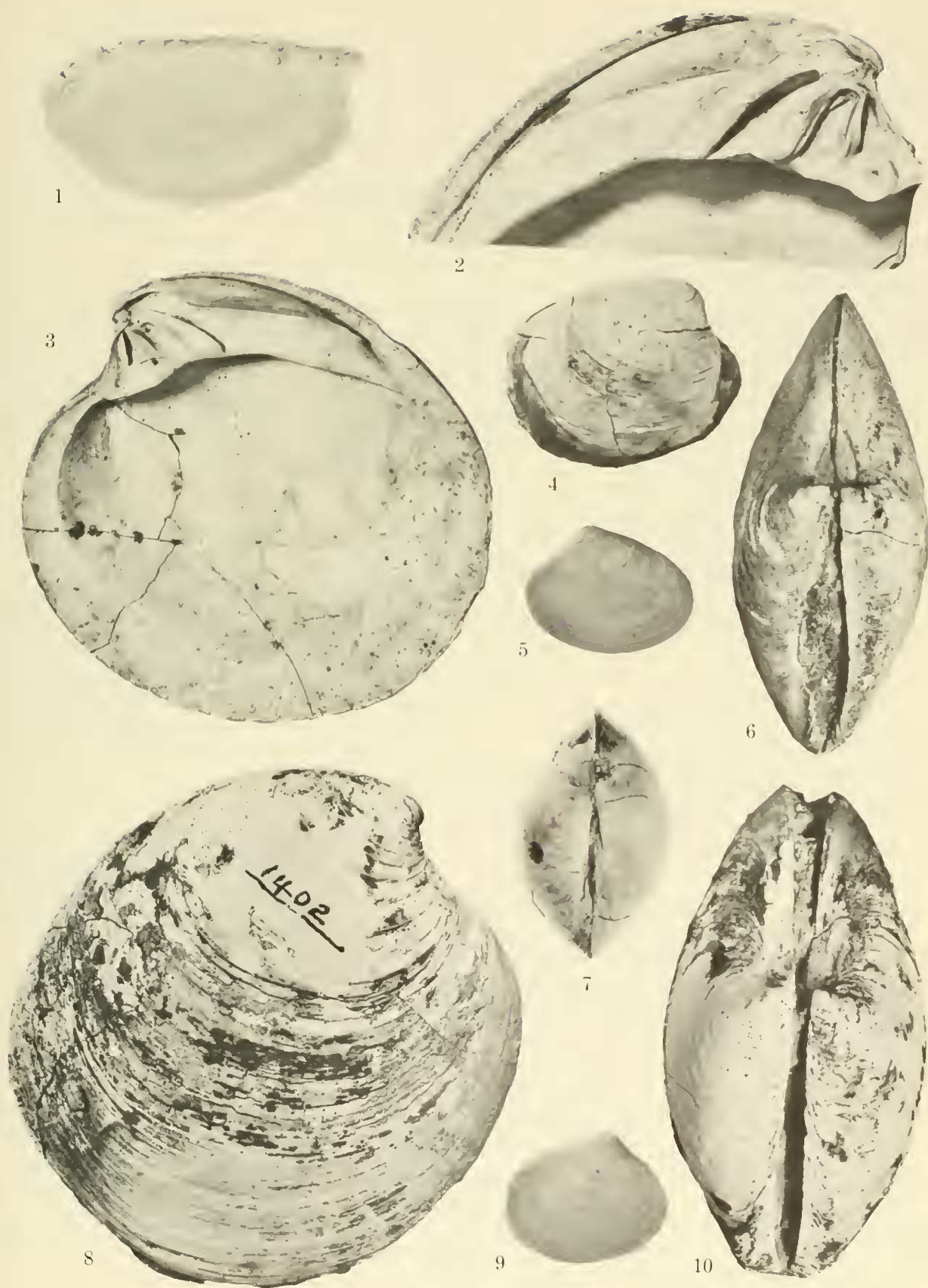


PLATE 48

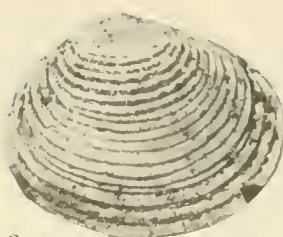
- Fig. 1. *Semele rubropicta* Dall. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 42.5 mm.; height 35.5 mm. View of the exterior of a left valve. P. 300
- Fig. 2. *Semele rubropicta* Dall. View of the exterior of the right valve of the specimen shown in fig. 1.
- Fig. 3. *Semele ashleyi* n. sp. Paratype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 29 mm.; height 23.6 mm.
- Fig. 4. *Semele* species. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 5.5 mm.; height 4.4 mm. View of the exterior of a small right valve. This is probably a juvenile shell of *Semele ashleyi* n. sp. P. 299
- Fig. 5. *Semele ashleyi* n. sp. Holotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 40.5 mm.; height 37 mm. View of the exterior of the left valve. P. 299
- Fig. 6. *Semele ashleyi* n. sp. Holotype. View of the exterior of the right valve of the specimen shown in fig. 5.
- Fig. 7. *Semele rubropicta* Dall. View of the dorsal area of the specimen shown in figs. 1 and 2. This view shows the small lunula-like area just anterior to the beaks. P. 300
- Fig. 8. *Semele* species. View of the interior of the specimen shown in fig. 4.
- Fig. 9. *Semele ashleyi* n. sp. View of the interior of the specimen shown in fig. 5.
- Fig. 10. *Semele ashleyi* n. sp. View of the interior of the specimen shown in fig. 6.
- Fig. 11. *Semele rubropicta* Dall. Hypotype (Los Angeles County Museum), from Loc. 318 (LAM), Knox Ranch hill, just above the gates and cow shed; 200 feet from the road and 30 feet above the valley floor, southwestern San Diego Co. Length 45.4 mm.; height 37.6 mm. View of the interior of a right valve. P. 300
- Fig. 12. *Solen rosaceus* Carpenter. Hypotype (Cat. No. 5006, San Diego Society of Natural History), from Mount Soledad, San Diego. Length 29.0 mm.; height 8.0 mm. View of the exterior of a right valve. P. 308
- Fig. 13. *Gobreaeus edentulus* Gabb. Hypotype (University of California at Los Angeles), from Loc. 2359 (UCLA), sandstone outcropping in a small canyon parallel to and about 0.2 mile west of the mouth of Rose Canyon and 0.4 mile north of Garnet Avenue, La Jolla quad., San Diego. Length 82.8 mm.; height 41 mm. View of the exterior of a right valve. P. 305
- Fig. 14. *Pandora (Pandorella) bilirata* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 3. Length 13.0 mm.; height 7.5 mm. View of the exterior of a right valve. P. 335
- Fig. 15. *Gobreaeus edentulus* Gabb. Hypotype (University of California at Los Angeles), from the same locality as the specimen shown in fig. 13. Length 80.5 mm.; height 41 mm. View of the exterior of a left valve. P. 305
- Fig. 16. *Donax (Serrula) gouldii* Dall. Hypotype (University of California at Los Angeles), from Loc. 294 (UCLA), 200 feet north of the Mexican boundary and $\frac{3}{4}$ mile east of the coast; exposure of strata in east-west ravine, tributary to a larger south-north ravine at right angle, in first terrace above the Tiajuana River plain. Length 14.5 mm.; height 8.7 mm. View of the exterior of a right valve. P. 303
- Fig. 17. *Pandora (Pandorella) bilirata* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 3. Length 13.0 mm.; height 8.0 mm. View of the exterior of a left valve. P. 335
- Fig. 18. *Pandora (Pandorella) bilirata* Conrad. View of the interior of the specimen shown in fig. 17.
- Fig. 19. *Donax (Serrula) gouldii* Dall. Hypotype (Los Angeles County Museum), from Loc. 319 (LAM), exactly between the United States-Mexico boundary fence and Mr. Erieson's (the manager's) house; 27 feet above the road level on the shoulder of the second hill. Length 14 mm.; height 9.8 mm. View of the interior of a right valve. P. 303



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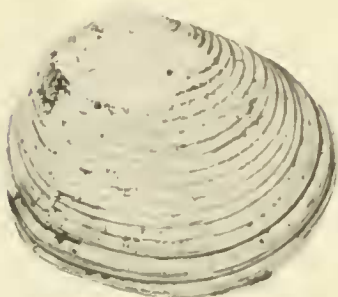
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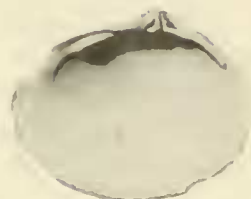
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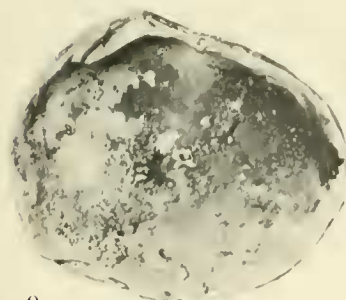
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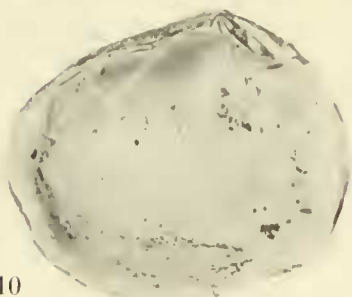
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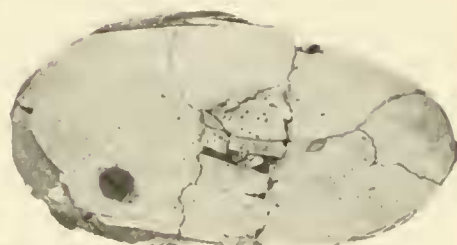
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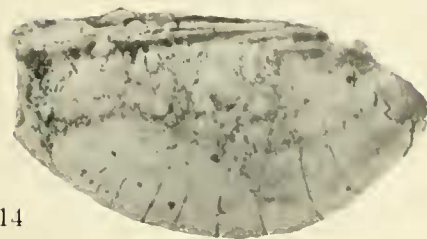
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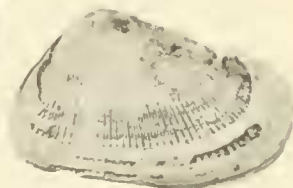
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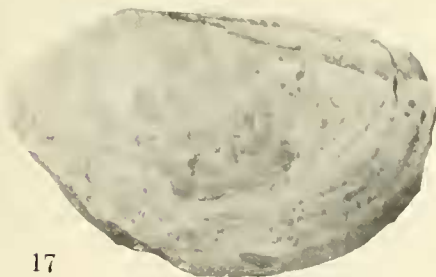
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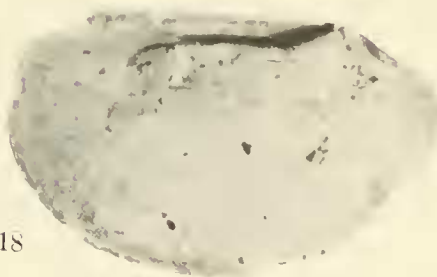
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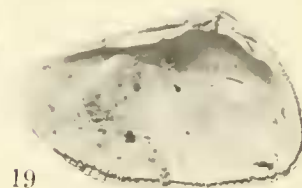
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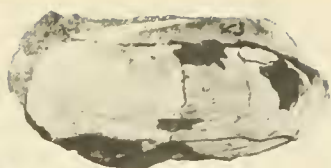
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PLATE 49

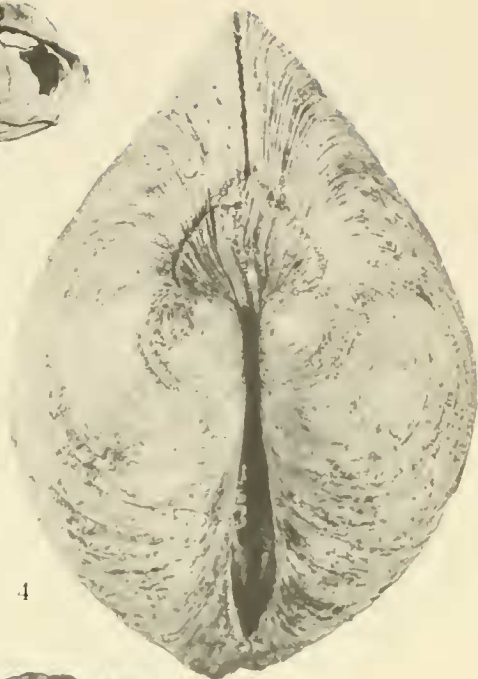
- Fig. 1. *Chione (Securella) kanakoffi* n. sp. Paratype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length (of portion shown) approximately 97 mm. View of the hinge area of a left valve. P. 279
- Fig. 2. *Siliqua lucida* Conrad. Hypotype (San Diego Society of Natural History), from Loc. 43 (SD), Reynard Way, San Diego. Length 38.2 mm.; height 16 mm. View of the exterior of a left valve. P. 311
- Fig. 3. *Chione (Securella) kanakoffi* n. sp. Holotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 129 mm.; height 122 mm. View of the exterior of the right valve. P. 274
- Fig. 4. *Chione (Securella) kanakoffi* n. sp. View of the dorsal area of the specimen shown in figs. 3 and 5.
- Fig. 5. *Chione (Securella) kanakoffi* n. sp. View of the exterior of the left valve of the specimen shown in figs. 3 and 4.
- Fig. 6. *Chione (Securella) kanakoffi* n. sp. Paratype (Los Angeles County Museum), from same locality as the specimen shown in fig. 3. Length 131 mm.; height 117 mm. View of the interior of a right valve. P. 274
- Fig. 7. *Solen sicarius* Gould. Hypotype (Cat. No. 5005, San Diego Society of Natural History), gulch No. 4, south slope of Mount Soledad, San Diego. Length 63 mm.; height 16 mm. View of a left valve.
- Fig. 8. *Dosinia (Dosinia) ponderosa diegouna* n. subsp. Paratype (California Academy of Sciences), from Loc. 1402 (CAS), on end of point between Cabrillo Canyon and a gulch about 100 meters south of the west end of Laurel Street bridge, across Cabrillo canyon, Balboa Park, San Diego. Length of area shown approximately 81.5 mm. View of the hinge area of a right valve. P. 265



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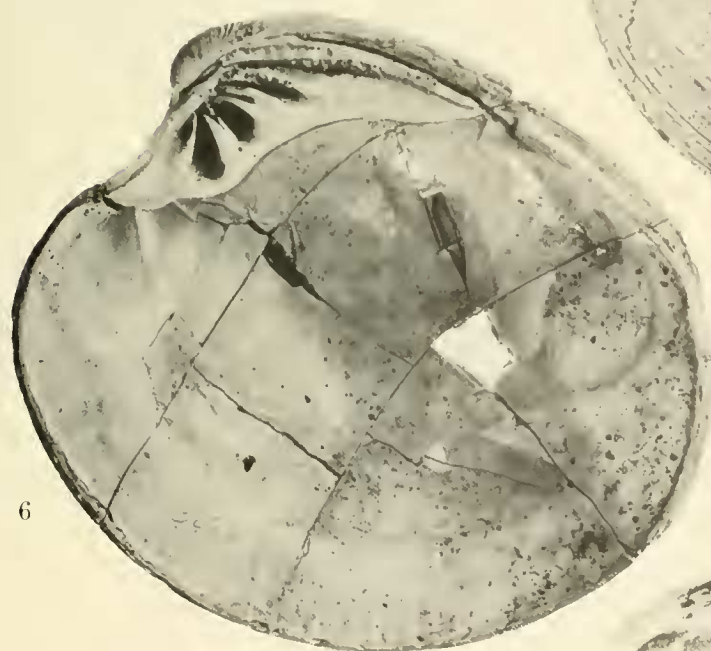
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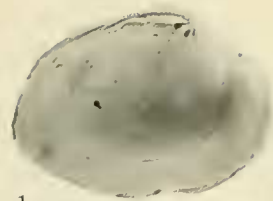
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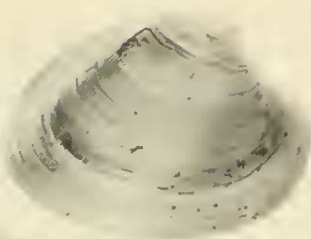
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PLATE 50

- Fig. 1. *Megapitaria squalida* Sowerby. Hypotype (Los Angeles County Museum), from Loc. 302 (LAM), exposure of strata across the street from the house at 2840 Columbia Street, San Diego. Length 38.3 mm.; height 29.6 mm. View of the interior of a left valve. P. 268
- Fig. 2. *Megapitaria squalida* Sowerby. From the same locality as the specimen shown in fig. 1. Length 46.2 mm.; height 35.5 mm. View of the exterior of a right valve. P. 268
- Fig. 3. *Megapitaria squalida* Sowerby. View of the interior of the specimen shown in fig. 2.
- Fig. 4. *Tivela (Pachydesma) stultorum* Mawe. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), second ravine north of Loc. L-294 (UCLA) and fifth ravine north (about $\frac{1}{4}$ mile) of the Mexican boundary, at west face of a terrace $\frac{3}{4}$ mile from the coast. Length 48 mm.; height 35 mm. View of the interior of a right valve. P. 266
- Fig. 5. *Tivela (Pachydesma) stultorum* Mawe. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 96.8 mm.; height 73 mm. View of the exterior of a left valve. P. 266
- Fig. 6. *Tivela (Pachydesma) stultorum* Mawe. View of the interior of the specimen shown in fig. 5.
- Fig. 7. *Macoma (Rexithaerus) indentata tenuirostris* Dall. Hypotype (San Diego Society of Natural History), from Loc. 331 (SD), 200 feet north of the Mexican boundary and $\frac{3}{4}$ mile from the coast, an exposure of strata of Pliocene age in an east-west ravine tributary to a larger south-north ravine at right angle, in first terrace above the Tiajuana River plain. Length 27.3 mm.; height 16.3 mm. View of the exterior of a left valve. P. 297
- Fig. 8. *Saridomus nuttalli latus* Stewart. Hypotype (California Academy of Sciences), from Loc. 12051 (H. Hemphill Coll.), from San Diego well. Length (incomplete) 118 mm.; height (incomplete) 79 mm. View of the interior of a right valve. P. 272
- Fig. 9. *Saridomus nuttalli* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 4. Length 97.5 mm.; height 75.5 mm. View of the exterior of a left valve.
- Fig. 10. *Saridomus nuttalli latus* Stewart. View of the exterior of the specimen shown in fig. 8.
- Fig. 11. *Irusella lamellifera* Conrad. Hypotype (University of California at Los Angeles), from Loc. 298 (UCLA), lowest *Pecten healeyi* bed, from just south of a ravine which is immediately south of the contact between the Eocene and the Pliocene strata, Pacific Beach. Length 27.4 mm. View of the exterior of a right valve, the apical area incomplete. P. 279



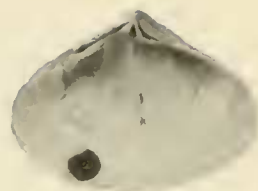
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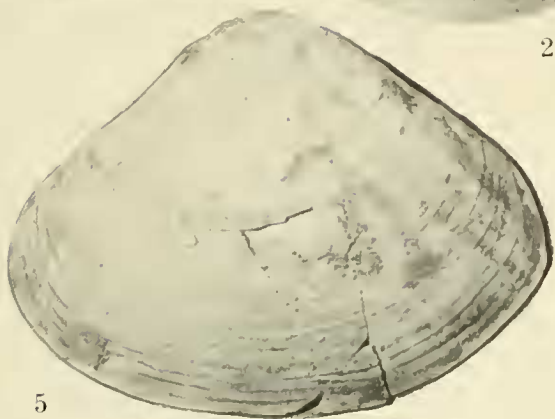
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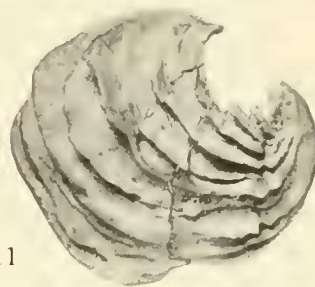
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PLATE 51

- Fig. 1. *Protothaca (Callithaca) tenerrima* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of gully next east of Loc. 305 (LAM), at the same elevation. Length of dorsal portion of the specimen, 56 mm. P. 277
- Fig. 2. *Protothaca (Callithaca) tenerrima* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 49.4 mm.; height 37 mm. View of the interior of a left valve. P. 277
- Fig. 3. *Protothaca (Callithaca) tenerrima* Carpenter. Hypotype (California Academy of Sciences), from Loc. 1402 (CAS), on end of point between Cabrillo Canyon and a gulch about 100 meters south of the west end of Laurel Street bridge across Cabrillo Canyon, Balboa Park, San Diego. Length of portion of specimen, approximately 98.0 mm. View of the hinge area of a right valve. P. 277
- Fig. 4. *Chione (Securella) kanakoffi* n. sp. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 17.7 mm.; height 18 mm. View of the exterior of a juvenile left valve.
- Fig. 5. *Chione (Securella) kanakoffi* n. sp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 19 mm.; height 16.5 mm. View of the exterior of a juvenile right valve. P. 274
- Fig. 6. *Chione (Securella) kanakoffi* n. sp. View of the interior of the specimen shown in fig. 4.
- Fig. 7. *Chione (Securella) kanakoffi* n. sp. View of the interior of the specimen shown in fig. 5.
- Fig. 8. *Psephidia ovalis* Dall. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 4.1 mm.; height 3.1 mm. View of the interior of the right valve shown on plate 47, fig. 9. P. 280
- Fig. 9. *Psephidia ovalis* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 8. Length 4.2 mm.; height 3 mm. View of the interior of the left valve shown on plate 47, fig. 5.
- Fig. 10. *Chione (Securella) kanakoffi* n. sp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 2. Length 131 mm.; height 117 mm. View of the exterior of the specimen shown on plate 49, fig. 6.
- Fig. 11. *Chione (Chione) allisoni* n. sp. Paratype (San Diego Society of Natural History), from Loc. 223 (SDSC), shell bed at base of cut and about 5 feet stratigraphically lower than Loc. 222 (SDSC). Length 27.5 mm.; height 25.8 mm. View of the exterior of a left valve showing the comparatively fine radial ribbing and close concentric lamellae. P. 273
- Fig. 12. *Chione (Chione) allisoni* n. sp. Paratype (San Diego Society of Natural History), from the same locality as the specimen shown in fig. 11. Length 27.5 mm.; height 25.2 mm. View of the interior of a right valve.
- Fig. 13. *Chione (Chione) allisoni* n. sp. View of the exterior of the specimen shown in fig. 12.
- Fig. 14. *Dosinia (Dosinia) ponderosa diegoana* n. subsp. Paratype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 2. Length 117 mm.; height 119 mm. View of the exterior of the right valve of the specimen shown on plate 47, fig. 6, which has been bored by a gastropod.
- Fig. 15. *Chione (Chione) allisoni* n. sp. Holotype (San Diego Society of Natural History), from Loc. 222 (SDSC), shell bed exposed at middle of south facing cut bank on corner lot at northeast corner of intersection of unnamed new streets, one of which is west of and parallel to Mount Soledad Road, the other (dead end) extends east of the first and is one block north of Kate Sessions Elementary School, San Diego. Length 32.6 mm.; height 27.2 mm. View of the exterior of a left valve. P. 273
- Fig. 16. *Chione (Chione) allisoni* n. sp. View of the interior of the specimen shown in fig. 15.

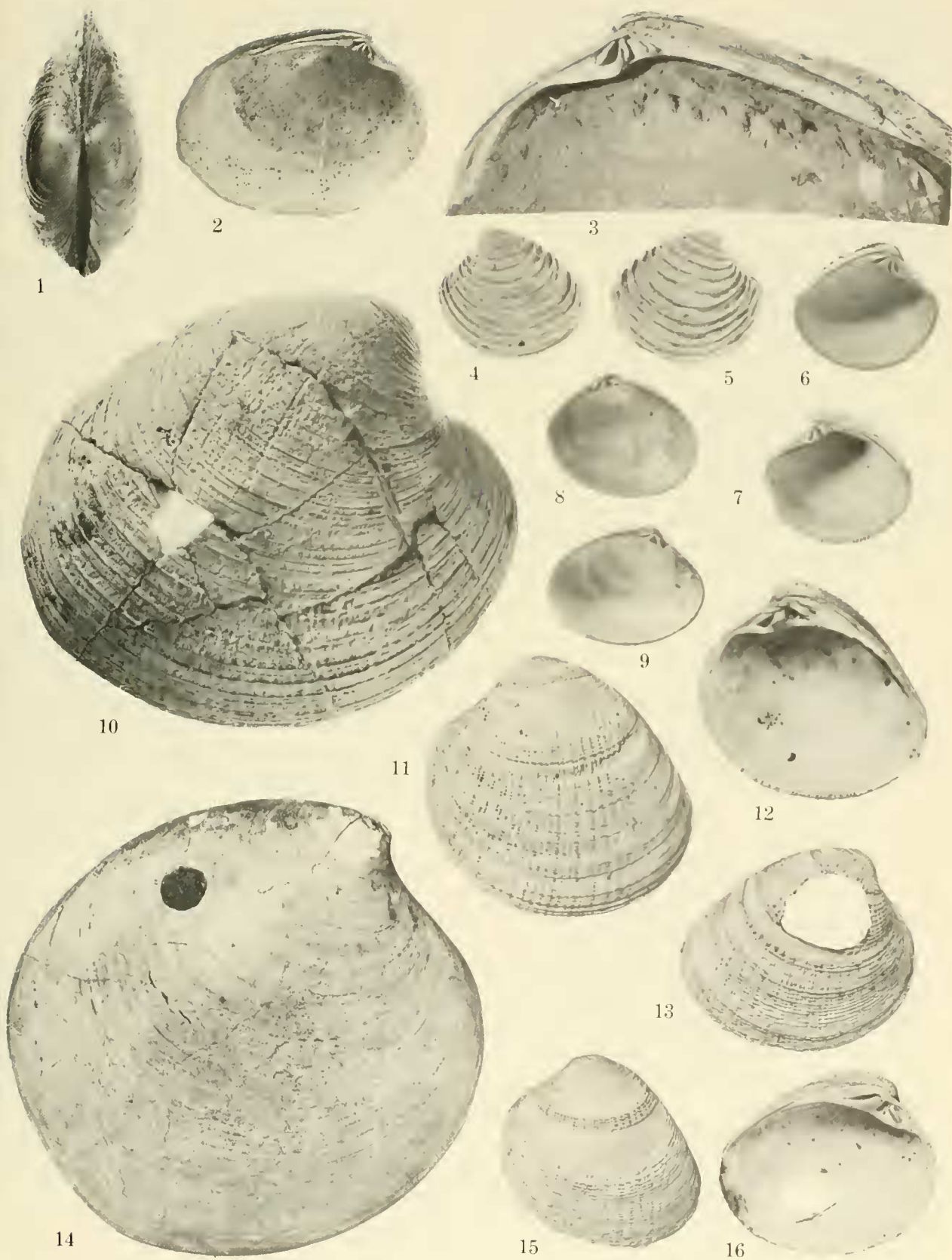


PLATE 52

- Fig. 1. *Macoma (Macoma) inquinata* Deshayes. Hypotype (Los Angeles County Museum), from Loc. 124 (LAM), shell and echini stratum 15 feet below level of floor of Snyder's Continuation School. Length 33.3 mm.; height 25 mm. View of the interior of a left valve. P. 292
- Fig. 2. *Macoma (Rerithaerus) indentata tenuirostris* Dall. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM) at the same elevation. Length 41.8 mm.; height 24.5 mm. View of the exterior of a right valve. P. 297
- Fig. 3. *Macoma (Rerithaerus) indentata* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 319 (LAM), exactly between the United States-Mexico boundary fence and Mr. Ericson's (the manager's) house, 27 feet above the road level on the shoulder of the second hill. Length 46 mm.; height 31 mm. View of the exterior of a right valve.
- Fig. 4. *Macoma (Rerithaerus) indentata* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 35.5 mm.; height 23.6 mm. View of the exterior of a right valve. P. 296
- Fig. 5. *Macoma (Macoma) nasuta kelseyi* Dall. Hypotype (Cat. No. 5679 San Diego Society of Natural History), from Cholla Valley, San Diego. Length 86 mm.; height 61 mm. View of the interior of a left valve. P. 294
- Fig. 6. *Macoma (Macoploma) medioamericana* Pilsbry and Olsson. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 2. Length 60.4 mm.; height 34 mm. View of the exterior of a left valve. P. 295
- Fig. 7. *Macoma (Rerithaerus) indentata* Carpenter. View of the interior of the specimen shown in fig. 4.
- Fig. 8. *Macoma (Macoploma) medioamericana* Pilsbry and Olsson. View of the interior of the specimen shown in fig. 6.
- Fig. 9. *Macoma (Macoma) nasuta kelseyi* Dall. Hypotype (San Diego Society of Natural History), from the same locality as the specimen shown in fig. 5. Length 85.8 mm.; height 58 mm. View of the interior of a right valve. Note the difference in the shape of the pallial sinus shown in this valve as compared to that in the left valve in fig. 5. P. 294
- Fig. 10. *Macoma (Macoma) inquinata* Deshayes. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 44 mm.; height 32.8 mm. View of the exterior of a right valve. P. 292
- Fig. 11. *Macoma (Macoma) nasuta kelseyi* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 84 mm.; height 60.5 mm. View of the exterior of a left valve. P. 294
- Fig. 12. *Macoma (Macoma) nasuta kelseyi* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 107 mm.; height 77 mm. View of the exterior of a right valve. P. 294
- Fig. 13. *Protothaca (Callithaca) tenerrima* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at the base of a hill 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Surv. topog. map, San Ysidro quad., revision 1953). Length 126 mm.; height 92.5 mm. View of the exterior of a left valve. P. 277
- Fig. 14. *Protothaca (Callithaca) tenerrima* Carpenter. View of the interior of the dorsal area of the specimen shown in fig. 13.

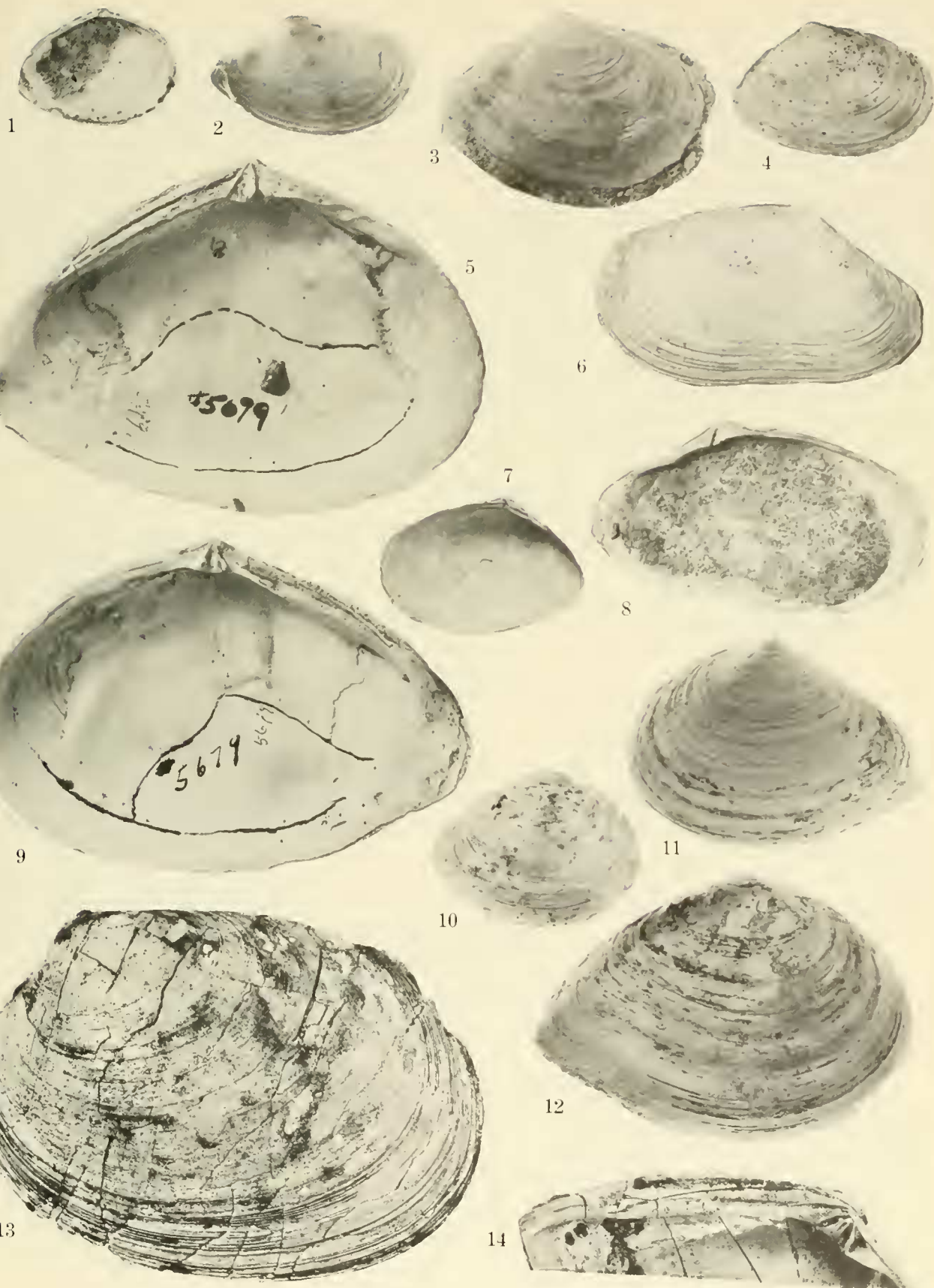


PLATE 53

- Fig. 1. *Tellina (Moerella) carpenteri* Dall. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1953). Length of area shown, approximately 9 mm.
- Fig. 2. *Tellina (Cadella) salmonea* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length of area shown approximately 5.0 mm. View of the hinge area of a left valve. P. 286
- Fig. 3. *Tellina (Cadella) salmonea* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 9.2 mm.; height 6.4 mm. View of the exterior of a right valve. P. 286
- Fig. 4. *Tellina (Cadella) salmonea* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 8.0 mm.; height 5.9 mm. View of the exterior of a left valve.
- Fig. 5. *Macoma (Macoma) elimata* Dunnill and Coan. Hypotype (University of California at Los Angeles), from Loc. 2359 (UCLA), sandstone outcropping in a small canyon parallel to and about two tenths of a mile west of the mouth of Rose Canyon and 0.4 mile north of Garnet Avenue, La Jolla quad. Length 27.7 mm.; height 27.8 mm. View of the exterior of a right valve. P. 291
- Fig. 6. *Tellina (Tellinella) idae* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 57.3 mm.; height 33.5 mm. View of the exterior of a right valve. P. 285
- Fig. 7. *Tellina (Moerella) carpenteri* Dall. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM), at the same elevation. Length 16.0 mm.; height 9.0 mm. View of the exterior of a right valve. P. 288
- Fig. 8. *Tellina (Cadella) salmonea* Carpenter. View of the hinge area of the specimen shown in fig. 3.
- Fig. 9. *Tellina (Peronidia) bodegensis* Hinds. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 51.8 mm.; height 25.5 mm. View of the exterior of a left valve. P. 289
- Fig. 10. *Macoma (Macoma) nasuta* Conrad. Hypotype (California Academy of Sciences), from Loc. 1178 (CAS), bluff at foot of Garnet Avenue, Pacific Beach. Length 30 mm.; height 21.3 mm. View of the exterior of a right valve. P. 293
- Fig. 11. *Tellina (Tellinella) idae* Dall. View of the interior of the specimen shown in fig. 6.
- Fig. 12. *Macoma (Macoma) acolasta* Dall. Hypotype (University of California at Los Angeles), from Loc. 1386 (UCLA), *Dosinia* beds in cut bank 338 feet farther along the ravine road (from Loc. 1385) and just below the southeast corner of the Federal Building, Balboa Park, San Diego. Length 25.6 mm.; height 15.4 mm. View of the exterior of a right valve. P. 290
- Fig. 13. *Macoma (Macoma) acolasta* Dall. View of the exterior of the left valve of the specimen shown in fig. 12.
- Fig. 14. *Florimetus biangulata* Carpenter. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), second ravine north of Loc. 294 (UCLA) and fifth ravine north (about $\frac{1}{4}$ mile) of the Mexican boundary at west face of a terrace $\frac{3}{4}$ mile east of the coast. Length 108 mm.; height 83.5 mm. View of the exterior of a right valve. P. 298
- Fig. 15. *Tellina (Moerella) carpenteri* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1.
- Fig. 16. *Tellina (Cadella) salmonea* Carpenter. View of the interior of the specimen shown in fig. 3.
- Fig. 17. *Florimetus biangulata* Carpenter. View of the interior of the specimen shown in fig. 14.
- Fig. 18. *Tellina (Peronidia) bodegensis* Hinds. Hypotype (University of California at Los Angeles), from the same locality as the specimen shown in fig. 14. Length 38 mm.; height 28.4 mm. View of the exterior of a right valve. P. 289
- Fig. 19. *Florimetus biangulata* Carpenter. Hypotype (University of California at Los Angeles), from the same locality as the specimen shown in fig. 14. Length 61.4 mm.; height 57.3 mm. View of the exterior of a left valve. P. 298



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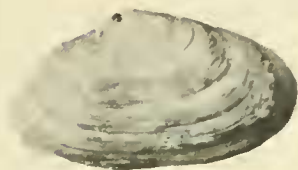
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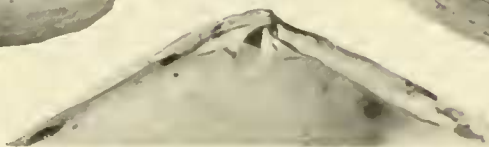
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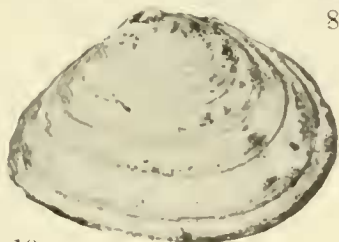
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PLATE 54

- Fig. 1. *Spisula (Mactromeris) hemphillii* Dall. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 112 mm.; height 87 mm. View of the exterior of a right valve. P. 315
- Fig. 2. *Spisula (Mactromeris) hemphillii* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Portion (47 mm. long) of a left valve showing hinge area.
- Fig. 3. *Spisula (Mactromeris) hemphillii* Dall. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM) at the same elevation. Length 123.6 mm.; height 94 mm. View of the exterior of a left valve. P. 315
- Fig. 4. *Spisula (Mactromeris) hemphillii* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 3. Portion (35.5 mm. long) of a right valve showing the hinge area. P. 315
- Fig. 5. *Spisula (Mactromeris) catilliformis* Conrad. Hypotype (Los Angeles County Museum), from Loc. 107 (LAM), 100-foot bluff with fossiliferous concretions in clay quarry at end of Arroyo Drive, San Diego. Length 91.6 mm.; height 74 mm. View of the exterior of a right valve. P. 313
- Fig. 6. *Macoma (Macoma) nasuta* Conrad. Hypotype (California Academy of Sciences), from Loc. 1178 (CAS), bluff at foot of Diamond Street, Pacific Beach. Length 21.5 mm.; height 30 mm. View of left valve of the specimen shown on plate 53, fig. 10. P. 293
- Fig. 7. *Spisula (Mactromeris) catilliformis* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 124 mm.; height 102 mm.
- Fig. 8. *Spisula (Mactromeris)* cf. *S. (M.) falcata* Gould. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 3. Length 18 mm.; height 11.6 mm. View of the exterior of a juvenile left valve. P. 314
- Fig. 9. *Spisula (Mactromeris) hemphillii* Dall. Hypotype (Cat. No. 2946, San Diego Society of Natural History), Reynard Way, San Diego. Length 134.5 mm.; height 102 mm. View of the exterior of a left valve. P. 315
- Fig. 10. *Cryptomya californica magna* Dall. Hypotype (California Academy of Sciences), from Loc. 1402 (CAS), on end of point between Cabrillo Canyon and a gulch about 100 meters south of the west end of Laurel Street bridge across Cabrillo Canyon in Balboa Park, San Diego. View of chondrophore of a left valve. Area illustrated approximately 20 mm. long. P. 320
- Fig. 11. *Tresus nuttallii* Conrad. View of the interior of the juvenile specimen shown on plate 55, fig. 9.
- Fig. 12. *Spisula (Mactromeris) mercedensis* Packard. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 5. Length 136 mm.; height 93 mm. View of a left valve.
- Fig. 13. *Cryptomya californica magna* Dall. Hypotype (California Academy of Sciences), from the same locality as the specimen shown in fig. 10. Length 49.5 mm.; height 35 mm. View of the exterior of a left valve. P. 320

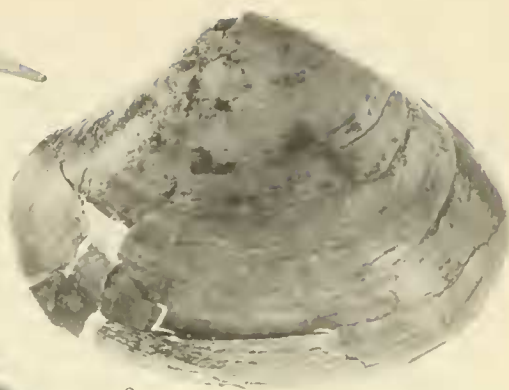
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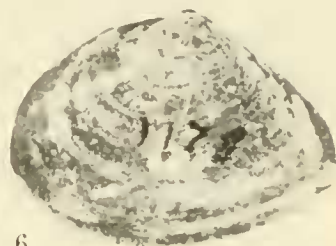
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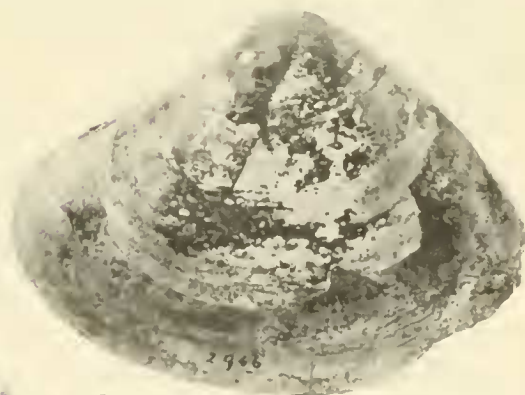
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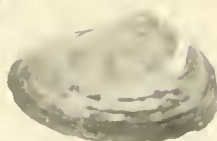
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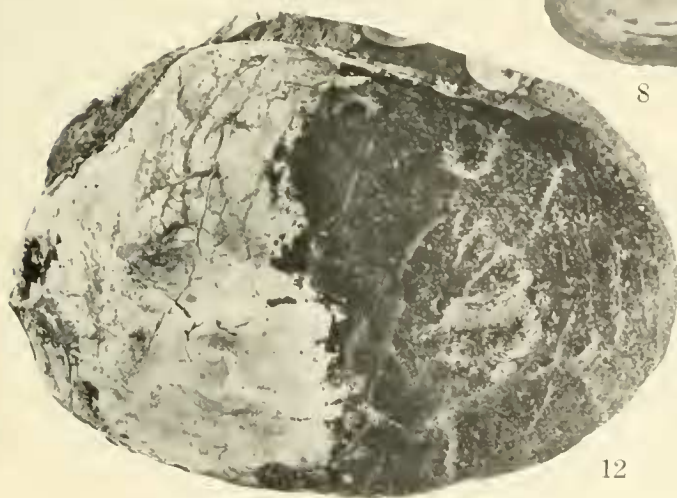
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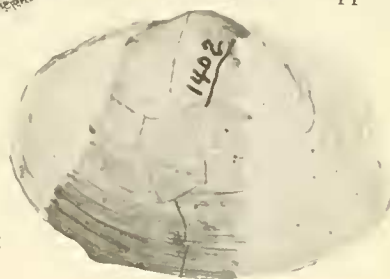


PLATE 55

- Fig. 1. *Corbula luteola* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., ed. 1943). Length 7.8 mm.; height 5.0 mm. View of the exterior of a left valve. P. 324
- Fig. 2. *Corbula luteola* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 8.1 mm.; height 5.6 mm. View of the exterior of a right valve. P. 329
- Fig. 3. *Cryptomya californica* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 16.4 mm.; height 12.2 mm. View of the interior of a somewhat rostrate right valve. P. 319
- Fig. 4. *Cryptomya californica* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 11.2 mm.; height 8.4 mm. View of the exterior of a right valve. P. 319
- Fig. 5. *Corbula luteola* Carpenter. View of the interior of the specimen shown in fig. 1.
- Fig. 6. *Corbula luteola* Carpenter. Hypotype from the same locality as the specimen shown in fig. 1. Length 7.9 mm.; height 5.4 mm. View of the interior of a right valve.
- Fig. 7. *Cryptomya californica* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 13.0 mm.; height (incomplete) 10.8 mm. View of the exterior of a rounded left valve. P. 319
- Fig. 8. *Cryptomya californica magna* Dall. Hypotype (California Academy of Sciences), from Loc. 1402 (CAS), on end of point between Cabrillo Canyon and a gulch about 100 meters south of the west end of Laurel Street bridge across Cabrillo Canyon in Balboa Park, San Diego. Length 44 mm.; height 31.5 mm. View of the exterior of a right valve and a portion of the ventral margin of the opposite valve. P. 320
- Fig. 9. *Tresus nuttallii* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 38 mm.; height 25 mm. View of the exterior of a juvenile right valve. P. 318
- Fig. 10. *Cryptomya californica* Conrad. View of the exterior of the specimen shown in fig. 3.
- Fig. 11. *Diplodonta (Diplodonta) orbella* Gould. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length (incomplete) 12.5 mm.; height 11.4 mm. View of the exterior of a somewhat elongated, juvenile left valve. P. 252
- Fig. 12. *Cryptomya californica magna* Dall. View of the left valve of the specimen shown in fig. 8.
- Fig. 13. *Tresus nuttallii* Conrad. Hypotype (University of California at Los Angeles), from Loc. 2420 (UCLA), bluffs along Pacific Beach about ½ mile southeast of False Point, La Jolla quad. Length 104 mm.; height 73 mm. View of the exterior of a left valve. P. 318
- Fig. 14. *Tresus nuttallii* Conrad. View of the exterior of the right valve of the specimen shown in fig. 13.
- Fig. 15. *Corbula luteola* Carpenter. View of the dorsal area of the specimen of which the right valve is shown in fig. 6, the left valve in fig. 1.
- Fig. 16. *Cryptomya californica* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 17.3 mm.; height 12.3 mm. View of the exterior of a right valve. P. 319
- Fig. 17. *Tresus nuttallii* Conrad. View of the dorsal area of the specimen shown in figs. 13, 14.

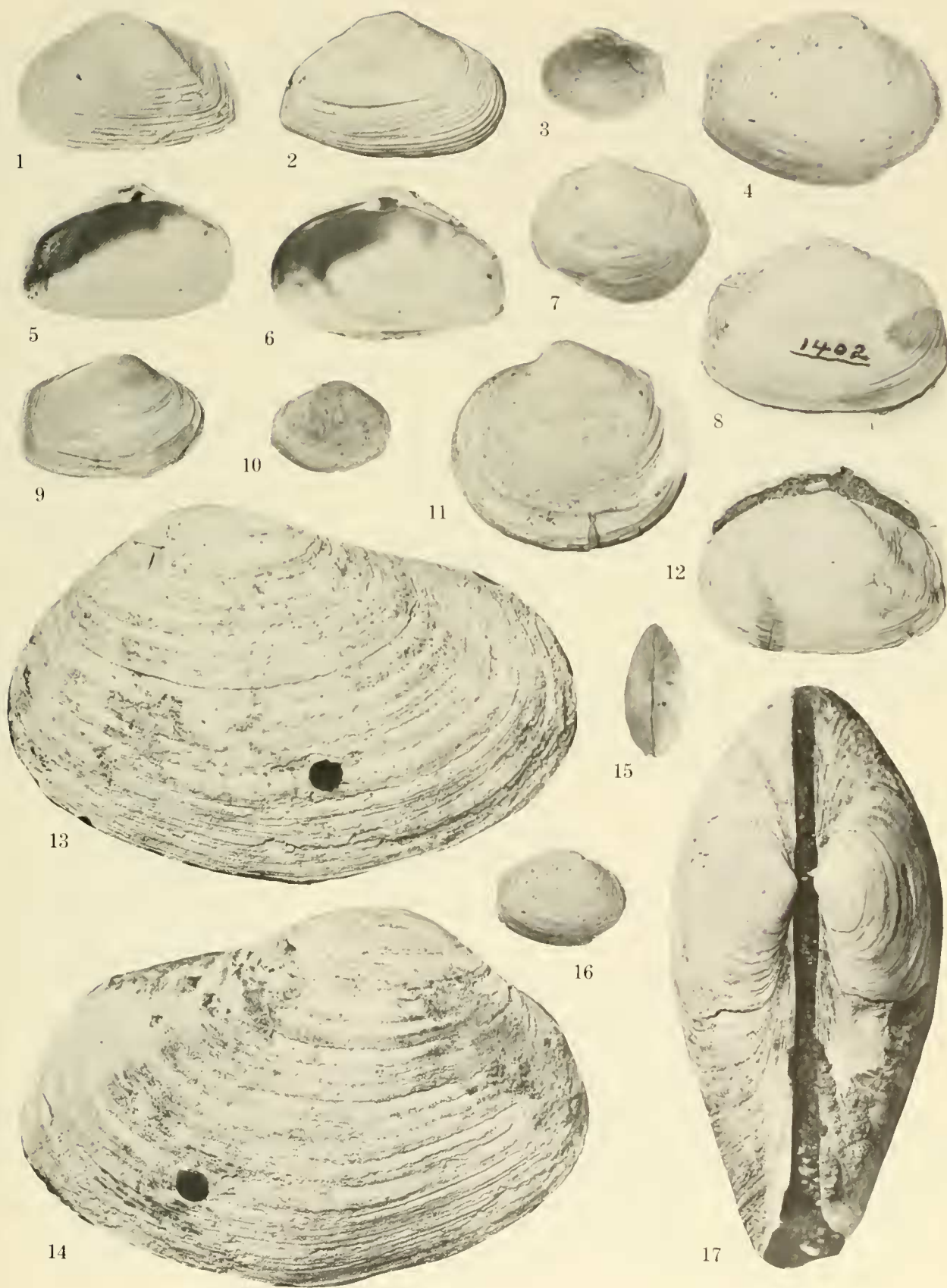


PLATE 56

- Fig. 1. *Miodontiscus prolongatus* Carpenter. Hypotype (Los Angeles County Museum), from Loc. 323 (LAM), under bridge between Fifth Street and the Radio Station, about 160 feet from the fence and about 350 feet from the Radio Station, San Diego. Length 6.7 mm.; height 7.8 mm. View of the exterior of a left valve. P. 233
- Fig. 2. *Miodontiscus prolongatus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.9 mm.; height 5.9 mm. View of the interior of a right valve. P. 233
- Fig. 3. *Miodontiscus prolongatus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.6 mm.; height 4.9 mm. View of this interior of a left valve. P. 233
- Fig. 4. *Miodontiscus prolongatus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 5.3 mm.; height 5.8 mm. View of the exterior of a right valve. P. 233
- Fig. 5. *Miodontiscus prolongatus* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 4.7 mm.; height 5.2 mm. View of the exterior of a right valve. P. 233
- Fig. 6. *Dermatomya tenuiconcha* Dall. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad. ed. 1943). Length 9.7 mm.; height 8.2 mm. View of the exterior of a right valve. P. 341
- Fig. 7. *Dermatomya tenuiconcha* Dall. View of the exterior of the left valve of the specimen shown in fig. 6.
- Fig. 8. *Penitella penita* Conrad. Hypotype (San Diego Society of Natural History), from Loc. 417 (SD), second ravine north of Loc. 331 (SD) and fifth ravine north (about $\frac{1}{4}$ mile) of the Mexican boundary at west face of the terrace, about $\frac{3}{4}$ mile from the coast. Length 52.3 mm.; height 28.5 mm. View of the exterior of a left valve. P. 333
- Fig. 9. *Penitella penita* Conrad. Hypotype (University of California at Los Angeles), from Loc. 312 (UCLA), same locality as the specimen shown in fig. 8. Length 51.4 mm.; height 29 mm. View of the exterior of a right valve. P. 333
- Fig. 10. *Dermatomya tenuiconcha* Dall. View of the interior of the specimen shown in fig. 6.
- Fig. 11. *Dermatomya tenuiconcha* Dall. View of the interior of the specimen shown in fig. 7.
- Fig. 12. *Panomya* cf. *P. beringiana* Dall. Hypotype (California Academy of Sciences), from Loc. 1418 (CAS), northeast corner of India and Spruce streets, San Diego. Length 44 mm.; height 38 mm. View of the exterior of a cast of a left valve. P. 329
- Fig. 13. *Dermatomya tenuiconcha* Dall. Enlarged view of the hinge area of the specimen shown in fig. 11.
- Fig. 14. *Tellina* (*Moerella*) *carpenteri* Dall. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM), at the same elevation. Length 14.6 mm.; height 9.9 mm. View of the exterior of a left valve. P. 288
- Fig. 15. *Hiatella arctica* Linnaeus. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 14. Length 5.6 mm.; height 1.3 mm. View of the exterior of a juvenile left valve. P. 326
- Fig. 16. *Penitella penita* Conrad. View of the interior of the specimen shown in fig. 9.
- Fig. 17. *Hiatella arctica* Linnaeus. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 14. Length 6.3 mm.; height 2.8 mm. View of the interior of a left valve. P. 326
- Fig. 18. *Hiatella arctica* Linnaeus. View of the exterior of the specimen shown in fig. 17.
- Fig. 19. *Panope generosa* Gould. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 14. Length 106 mm.; height 72 mm. View of the dorsal area. P. 328
- Fig. 20. *Panope generosa* Gould. View of the exterior of the right valve of the specimen shown in fig. 19.
- Fig. 21. *Sphenia* cf. *S. laticola* Valenciennes. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 6. Length 3.8 mm.; height 2.7 mm. View of the exterior of a left valve. P. 321
- Fig. 22. *Sphenia* cf. *S. laticola* Valenciennes. View of the interior of the specimen shown in fig. 21.

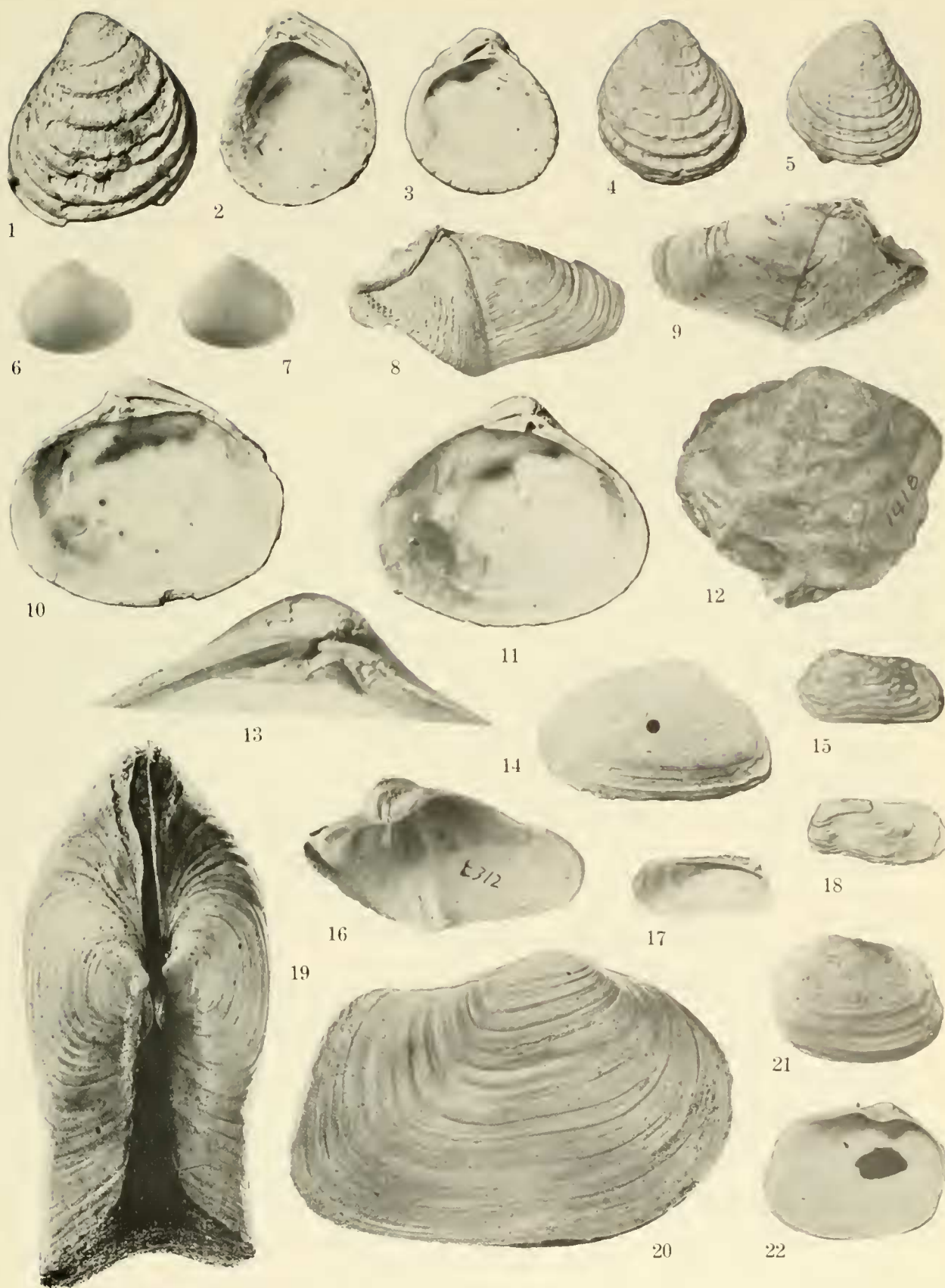


PLATE 57

- Fig. 1. *Penitella penita* Conrad. Hypotype (Los Angeles County Museum), from Loc. 107 (LAM), clay quarry at end of Arroyo Drive, San Diego. Length 47.2 mm.; height 30.4 mm. Dorsal view. P. 333
- Fig. 2. *Penitella penita* Conrad. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 1. Length 44.4 mm.; height 25.9 mm. View of the exterior of a right valve. P. 333
- Fig. 3. *Corbula gibbiformis* Grant and Gale. Hypotype (University of California at Los Angeles), from Loc. 2359 (UCLA), in small canyon parallel to and about 0.2 mile west of the mouth of Rose Canyon and 0.4 mile north of Garnet Avenue, La Jolla quad., San Diego. Length 14.9 mm.; height 14.6 mm. View of the interior of a right valve. P. 323
- Fig. 4. *Corbula gibbiformis* Grant and Gale. View of the exterior of the specimen shown in fig. 3.
- Fig. 5. *Penitella couradi* Valenciennes. Hypotype (Los Angeles County Museum), from Loc. 305C (LAM), exposure at base of hill, 100 feet west and 440 feet south of the northeast corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian (see U.S. Geol. Survey topog. map, San Ysidro quad., revision 1953). Length 25 mm.; height 20.3 mm. View of the exterior of the left valve. P. 332
- Fig. 6. *Basterotia* (*Basterotella*) *hertleini* Durham. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 5. Length 11 mm.; height 7.3 mm. View of the interior of a right valve. P. 241
- Fig. 7. *Ensis myrae* Berry. Hypotype (Los Angeles County Museum), from Loc. 305A (LAM), west side of next gully east of Loc. 305 (LAM), at the same elevation. Length (incomplete) 14 mm.; height 8.6 mm. View of the interior of the anterior end of a left valve. P. 309
- Fig. 8. *Donax* (*Serrula*) *gouldii* Dall. Hypotype (Los Angeles County Museum), from Loc. 319 (LAM), exactly between the United States-Mexico boundary fence and Mr. Ericson's (the manager's) house, 27 feet above the road level on the shoulder of the second hill. Length 21.2 mm.; height 10.9 mm. View of the exterior of a left valve. P. 303
- Fig. 9. *Diplodonta* (*Diplodonta*) *orbella* Gould. Hypotype (Los Angeles County Museum), from Loc. 305 (LAM), 2400 feet east and 1350 feet south of the northwest corner of Sec. 8, T. 19 S., R. 2 W., San Bernardino Base and Meridian, southwestern San Diego Co. Length (approximately) 18 mm.; height 17 mm. View of the exterior of a right valve, the posterior margin incomplete. P. 252
- Fig. 10. *Lima* (*Limaria*) *orcutti* Hertlein and Grant. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 5. Length 35.8 mm.; height 44.8 mm. View of the exterior of a right valve. P. 215
- Fig. 11. *Basterotia* (*Basterotella*) *hertleini* Durham. View of the exterior of the specimen shown in fig. 6.
- Fig. 12. *Spisula* (*Mactromeris*) cf. *M. (M.) planulata* Conrad. Hypotype (University of California at Los Angeles), from Loc. 294 (UCLA), 200 feet north of Mexican boundary and $\frac{3}{4}$ mile east of the coast, exposure in east-west ravine tributary to a larger south-north ravine at right angle, in first terrace above Tiajuana river plain. Length 31.7 mm.; height 25.3 mm. View of the exterior of a right valve.
- Fig. 13. *Penitella couradi* Valenciennes. Dorsal view of the specimen shown in fig. 5. P. 332
- Fig. 14. *Cuspidaria* (*Cardiomya*) *pectinata* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 7 mm.; height 4.2 mm. View of the exterior of a right valve. P. 342
- Fig. 15. *Compsomya subdiaphana* Carpenter. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 9. Length 32.7 mm.; height 26.4 mm. View of the exterior of a right valve, umbonal portion incomplete. P. 269
- Fig. 16. *Spisula* (*Mactromeris*) *hemphillii* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 9. View of a portion of a right valve 54 mm. long, showing the hinge. P. 315
- Fig. 17. *Nuculana* aff. *N. leonina* Dall. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 9. Length 8.6 mm.; height 1.8 mm. View of the interior of a right valve. P. 149
- Fig. 18. *Diplodonta* (*Diplodonta*) *orbella* Gould. View of the interior of the specimen shown in fig. 9.
- Fig. 19. *Ensis myrae* Berry. Hypotype (Los Angeles County Museum), from the same locality as the specimen shown in fig. 7. Length 65.8 mm.; height 10.1 mm. View of the exterior of a right valve embedded in sediment in the interior of a left valve of *Spisula hemphillii* Dall. P. 309
- Fig. 20. *Nuculana* aff. *N. leonina* Dall. View of the exterior of the shell shown in fig. 17.

